CQ VHF

Ham Radio Above 50 MHz

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Spring 2006

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Greater Range at 100,000 Feet

- Multi-Band Rover Contesting
- Connecting Wires to Rocks
- D-STAR Test Results

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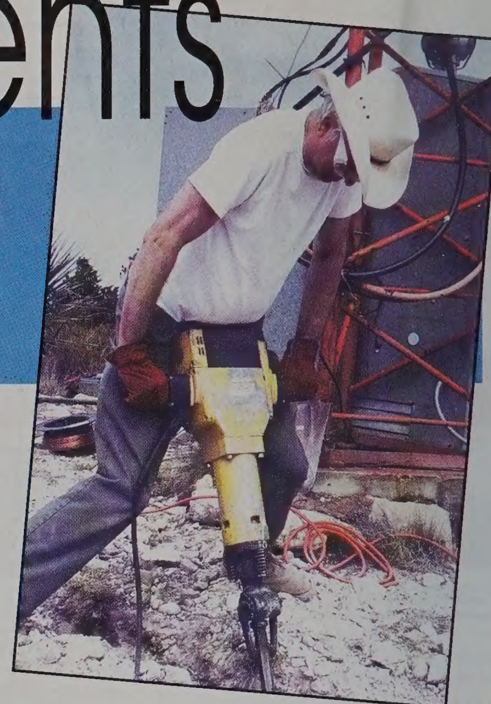

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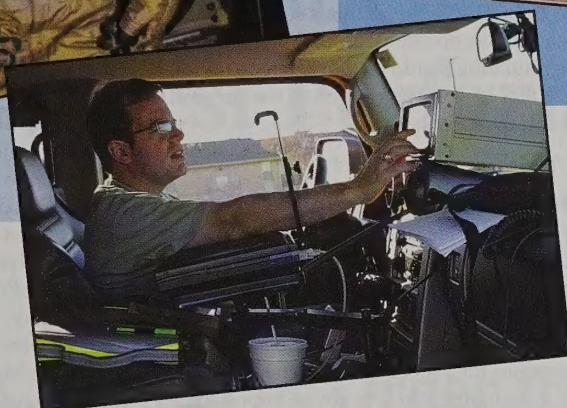
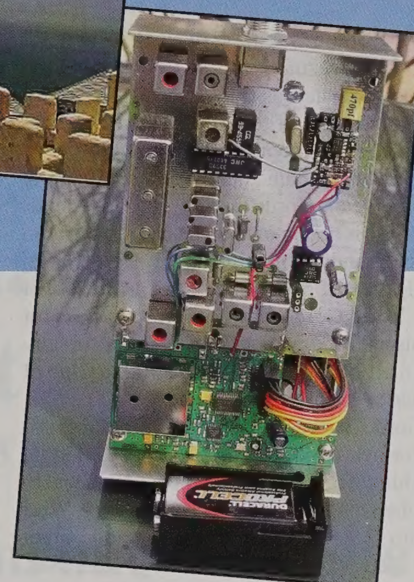
FEATURES





COLUMNS

DEPARTMENTS

On The Cover: Rather than climb a mountaiin to get greater range on VHF, consider using a weather balloon to get the electronics aloft. In this photo WC5Z is shown with a "little" direction-finding antenna used to track the balloon. For details, see the story on page 8. (Photo by Bobette Doerrie, N5IS)

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

Gordon West, WB6NOA, Ham of the Year

Gordon West, WB6NOA, *CQ VHF* magazine Features Editor, has been selected as the 2006 Dayton Hamvention® Ham of the Year. He will be honored later this month at the convention.

A licensed ham radio operator for more than 40 years, Gordo (as he prefers his friends call him) is best known for teaching ham radio classes and publishing study guides. An ARRL Certified Instructor and Instructor of the Year, Gordo has been responsible for thousands of amateur radio operators obtaining their licenses. He is also a Radio Club of America fellow.

Gordo has been teaching ham radio classes for nearly 40 years. In the 1980s, Gordo and his wife Suzy, N6GLF, began team teaching their classes under the name Gordon West Radio School. These classes include night and weekend sessions on college campuses, in county and city government buildings, and even at marinas. Wherever interested persons gather, be it 75 or 200, there is Gordo promoting the hobby. He also teaches classes for Commercial Radio operators, as well as providing free Technician Class amateur radio license training for youth and certified emergency responders for community emergency response teams (CERT).

Gordo also teaches ham radio classes annually for the Northern California Handiham Radio Camp. In addition, he volunteers with the American Red Cross communications team in Orange County, California. Commenting on these volunteer activities, Gordo says that it is his way of giving something back to a lifetime hobby that has meant so much to him.

Gordo has published hundreds of articles on amateur radio, commercial radio, and CB radio. At one time in the late 1970s, Gordo was the editor of *CB Magazine,* succeeding the late Leo Sands. A bit of trivia that Gordo doesn't remember is that once, while serving as editor of *CB Magazine,* he sent me a rejection letter.

The reverse has never been the case with me as the editor of *CQ VHF,* however. I am happy to have Gordo as one of the feature editors of this magazine. He has contributed at least 20 articles and shorts to *CQ VHF* since its rebirth four years ago at Dayton.

Gordo lives in Costa Mesa, California, where he has stations operational from 3.5 MHz to 10 GHz. A recent tornado, a rare occurrence in the area, damaged his towers and beams, but that hasn't deterred Gordo from spending at least a couple of hours a day encouraging new hams to get on the air via the many nets that he runs.

We at *CQ VHF* magazine join with scores of ham radio operators around the world in congratulating Gordo on this fine recognition of all that he has contributed to the survival and future of our hobby.

In This Issue

From bottoms to tops: From the bottom of the sunspot cycle to the top of the sky, this issue contains articles that appeal to both extremes of our niche in the hobby. Regarding the bottom of the sunspot cycle, Lance Collister, W7GJ, writes about the many considerations for a successful 6-meter EME station, concluding that it is not an impossibility for the average operator to be on the moon on this band. Also pertaining to the bottom of the sunspot cycle is the Propagation column by Tomas Hood, NW7US, who writes about the prediction that the next solar cycle will be a dandy.

Regarding the top of the sky, the husband-and-wife team of Jerome, K5IS, and Bobette, N5IS, Doerrie write about how to achieve a wider (albeit temporary) coverage of 2-meter communications from the relatively flat lands of the northern tip of the Texas panhandle by way of a surplus weather balloon. Also writing about the sky is Airborne Radio columnist Del Schier, K1UHF, who covers radio systems in model aircraft.

Going even higher in the sky, all the way up to the International Space Station, is Keith Pugh, W5IU, who writes about the first dual-orbit ARISS QSOs that took place in February and involved a school in Dale, Oklahoma on the first orbit and an elementary school in Dallas, Texas on the second orbit. Keith also covers the latest activities from space in his Satellites column.

Even higher up, Antennas columnist Kent Britain, WA5VJB, writes about constructing antennas for GPS receivers. Going into deep space is Paul Shuch, N6TX, who again covers the search for extraterrestrial intelligence. A bit closer to home is a new column that Paul is starting with this issue. Entitled The Orbital Classroom, in this column he explores ways in which amateur radio communications in space can be used educationally to encourage young people to become part of our hobby.

From the bottom to the top of the microwave bands is Steve Hicks, N5AC, who writes about bandswitching across the microwave spectrum while contesting as a rover. Also on top of the microwave bands is Gordon West, WB6NOA, who tells how to encourage the FM operator to consider operating on 10 GHz.

Speaking of contesting, Kevin Kaufhold, W9GKA, writes about the historical trends of *CQ* magazine sponsored VHF contests. The statistical model that he uses is detailed in a paper entitled "A Statistical Model of VHF Contest Activity," to be published in the 2006 Conference *Proceedings* of the Central States VHF Society.

Somewhere in the middle of the VHF spectrum is Joe Moell, KØOV, who writes in his Homing In column about pulsed emitters near 220 MHz. Speaking of homing in, Joe recently announced that the OH-KY-IN Amateur Radio Society is conducting a special hidden-transmitter hunt championship for blind and visually impaired persons during the Dayton Hamvention®. For more information on this unique T-hunt visit the website <http://www.ardfusa.com/>.

Speaking of the bottom, this time meaning the ground, Larry Higgins, W5EX, and Joe Jankowski, W5KTX, tell how to get a good ground in rocky soil by literally connecting wires to rocks. When it comes to getting a good earth ground in the boonies, there is no more pounding rocks for these two hams.

Regarding far-out digital communications, HSMM columnist John Champa, K8OCL, tells of the 6-meter experiment now under way that pertains to the long-range transmission of digital data on that band. Also pertaining to digital communications, ICOM's Amateur and Receiver Products Division Manager, Ray Novak, N9JA, reveals how D-STAR was used successfully by the US Army and FEMA in field tests earlier this year.

There you have it: From top to bottom and from cover to cover, in your hands is another great edition of the magazine with the best coverage of our niche in the wonderful hobby of amateur radio. Perhaps the next issue will contain a contribution from you. If so, I look forward to receiving your query about writing for *CQ VHF* magazine.

Until the next issue…

73 de Joe, N6CL

Considerations for Successful 6-Meter EME DXpeditions

As the bottom of the sunspot cycle nears, faithful 6-meter DXers seemingly are stalled in their quest to increase their countries worked totals. The only way around this dilemma is via EME. W7GJ tells how to make those EME QSOs happen on the Magic Band.

By Lance Collister,* W7GJ

Until only a few years ago, the prospects of using the moon to complete a 6-meter contact with a rare DXpedition or portable station were extremely remote. However, the increased sensitivity of the recently developed JT65 digital modes by K1JT greatly enhances the viability of such "Ultra Long Path" contacts. It is assumed that JT65A mode will be a key element to success in any 6-meter EME DXpedition, and also that interested 6-meter EME operators are already familiar with this mode. The standard mode for communications on 6-meter EME has become JT65A, which is the most sensitive of the JT65 modes. Detailed instructions of how to effectively use the WSJT software for JT65A EME contacts are available elsewhere and will not be covered here. New JT65 users are urged to review the following sites:

<http://www.bigskyspaces.com/w7gj/JT65checklist.htm>
<http://pulsar.princeton.edu/~joe/K1JT/Documentation.htm>

Our current time near the bottom of the solar cycle is the optimum time for 6-meter EME, and the amount of activity on it has been increasing dramatically. Remember that an EME station with a larger antenna essentially "makes up for" a smaller antenna on the DXpedition end of the circuit. Therefore, the increasing number of larger home stations (both with and without elevation) greatly increases the chances for success by a smaller DXpedition station, provided certain considerations are addressed well in advance. In fact, the portable 6-meter EME station now can probably fill up as much time as is desired on EME contacts, within the constraints of available moon time.

This is by no means to suggest that 6-meter EME is commonplace or trivial. In fact, nothing could be further from the truth! Six meters remains one of the most difficult bands on which to operate moonbounce, and the situation is exacerbated by the fact that 50 MHz signals are high enough in frequency to be affected by tropospheric ducting and low enough to be adversely affected by just about any kind of perturbation in the ionosphere. Of course, too, even when conditions are most favorable for EME, you always run the risk that Faraday rotation will change the polarity so that one (or both) stations will not be able to copy the other! This polarization shift is what makes it very rare for two stations to be copying each other at the same time, and is the reason why EME schedules are often so long—to permit each station to have a chance to exchange required contact information with the other.

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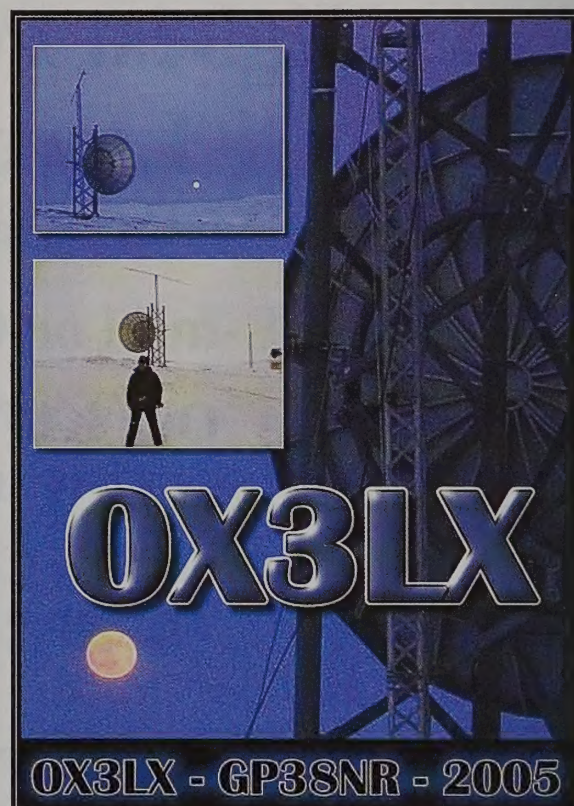
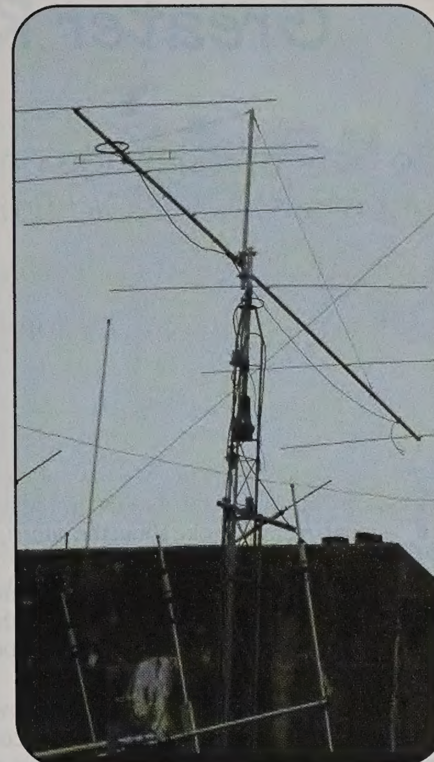


M^2 6M7 antenna at OX3LX, March 2005. (Photo courtesy of OZ1DJJ)

Certainly, if you are a DXpeditioner strictly interested in the number of contacts with the simplest equipment, HF is a much more attractive option. However, if you enjoy the challenge as well as the reward in overcoming the odds and completing contacts by sending signals 3/4 million kilometers, then you are just the type of DXer for 6-meter EME! I have always thought of EME DXing as having much in common with fly fishing. If your primary interest is to obtain a large number of fish, you could drive to the fish market. However, if you are more interested in relying on yourself, in a way that will require all your skill and cunning, then fly fishing will be more thrilling and rewarding—even if some get away! Like fly fishing, it is the challenge of the adventure and the process–plus the thrill of actually landing one—that makes it so rewarding!

Six-meter EME array at W7GJ ($4 \times M^2$ 6M9KHW fed with $1^5/_8$-inch heliax).



M^2 6M7JHV Yagi installed above the Jersey Amateur Radio Club in May 2005. (Photo courtesy of GJ8BCG)

There are a number of different approaches that can be used by a successful 6-meter DXpedition station, and it is not my intent here to attempt to prescribe any single protocol that has emerged as being most successful. Because this is such a new aspect of 6-meter DXing, we are all learning from the experience of each DX operation. However, there are definitely certain subject areas which will need to be considered prior to embarking on a successful DXpedition, and I hope to discuss a few of these elements that are particularly relevant to 6-meter moonbounce in order to assist stations thinking about preparing for 6-meter DXpeditions. I also will suggest some possible operating options that have come to light through recent 6-meter EME DXpeditions that might be used to increase effectiveness during future operations.

Planning

Certainly, the first thing to consider when you are selecting a location to set up for a 6-meter EME DXpedition is to find a good quiet location. For most of us, the local noise that surrounds us where we live is something beyond our control. There are many people who live in urban areas who constantly struggle with high noise levels and cannot imagine adding a preamp to make their receivers sensitive enough to copy weak signals on the 50-MHz band! One of the advantages offered by a chance to set up a portable EME station is the possibility of finding a place to avoid the high noise that plagues so many stations on the "Magic Band." Ideally, you will be able to find a spot that will not require you to aim the antenna toward high-power RF transmitters, industrial areas, noisy street lights, power lines, or other noise sources that will mask weak signals.

(Continued on page 65)

FT5XO 6-meter antenna (M^2 6M7NAN "Trip Yagi"), March 2005. (Photo courtesy of W7EW)

Greater Range at 100,000 Feet

"To get greater range on VHF, get your antennas higher. Go climb a mountain."—*The Old Timer*

By Jerome,* K5IS, and Bobette,† N5IS, Doerrie

There's not much in the way of mountains on the high plains of the Texas and Oklahoma panhandles. The local weak-signal operators joke about the interstate overpasses being 20-dB hills.

The ARRL Antenna Book lists the formula for line-of-sight radio horizon as D (miles) = 1.415 times the square root of the antenna height in feet. An altitude of 10,000 feet yields a range of 142 miles.

We considered erecting a 10,000 foot tower, but quickly discarded that idea. A small private airplane could easily reach this altitude and would be much cheaper than the tower. We have operated radios from the back seat of an airplane in spite of the engine noise. We knew there had to be a better way, though.

Operating on the summit of one of the 14,000 foot mountains in Colorado gives a similar communications range. However, weather factors cause operator discomfort.

If radios can be carried to 100,000 feet, the range becomes 447 miles, providing the possibility of stations 800 miles apart being able to communicate for a few minutes. Placing the antenna and radio equipment at 100,000 feet over Booker (northeast corner of the Texas panhandle), the communications range could reach hams near Dallas, Albuquerque, Denver, and Kansas City. The challenge becomes one of how to climb to 100,000 feet and still maintain operator comfort.

The solution: Use a weather balloon to carry the electronics aloft.

In the fall of 1992, Bobette, a high school physics teacher, started the Perryton High School Reach for Space program as an enrichment project for her science students. Our first balloon flight was in the spring of 1993. In this article we describe some of our experiences and tell what we have learned over the past 13 years from flying "weather" balloons up into the thin air of near space.

First We Thought We Needed Balloons

It began when Bobette attended a presentation on remote sensing at the state science teachers conference. A contest called SkyView, sponsored by the Texas Space Grant Consortium, involved taking pictures from a platform in the air—either a balloon or a kite. It had obvious amateur radio applications, because the camera probably would need radio signals to trigger it.

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Photo A. It takes a committee to prepare the payload, especially when there are problems. (All photos courtesy the authors)

In 1992 at a hamfest in Amarillo, Texas, we found a surplus dealer with a case of weather balloons. A deal was made and we had balloons. We knew nothing about lift capacity, ascent rates, burst altitude, tracking, recovery, amounts of helium needed, regulations, or the effect of age on latex balloons. We had balloons and we began our journey on the learning curve.

At that time, published information on the subject was very difficult to find. Bill Brown, WB8ELK, was encouraging ATV interest groups to use balloons as a platform for television repeaters. Details of various first flights were featured in his *73 Magazine* ATV column. We read several of the articles and decided we were ready to fly.

On a Saturday in March 1993, painter's drop cloths were spread on the floor of the auto shop at Perryton High School. Payload pieces were assembled in a Styrofoam™ picnic cooler. Balltrack (DOS version) was running on a computer. A Samsung 35-mm camera was taking pictures of shoe laces every three minutes. In addition, a label with our contact information and offer of a reward if the payload was found by someone else was taped to the cooler.

The balloon, a surplus 1400-gram Kaysam, was getting larger and larger as it filled with helium. We thus thought it would be a good idea to finish the filling process outside. There is something about helium filling a balloon that just seems to cause wind to appear. It's magic! In this case, as the balloon was inflating some wind started spinning our balloon around and around, twisting the neck tight. The helium had to be shut off and the balloon untwisted.

After a few minutes, which seemed like forever, the balloon was fully inflated. While we were attaching the payload to the balloon at the neck, the balloon envelope broke free, flying about as if it were an escaped bird. The payload stayed behind for us to stumble over.

From this initial experience we learned two lessons:

Lesson 1: *Don't start the camera until just before liftoff.*

Lesson 2: *Have extra helium on hand.* We had more balloons, but were out of helium.

With having learned these lessons, we were now initiated into the Fraternal Order of Ham Balloonists!

It was the same song, second verse when preparations were under way for launch in July. Again we used the school's auto shop, but this time because of strong surface wind gusts we finished filling the balloon inside. When we took the balloon outside, we had difficulty clearing the building and vehicles before releasing the balloon.

The sight of the ascending balloon and payload was beautiful and enhanced by the shouts of joy from the launch team. The Balltrack predictions indicated the flight would start out to the northeast and then loop back around and travel 100 miles west in six hours. We thought we had lots of time, so we let our attention wander from the balloon, and 93 minutes into the flight the beacon signals vanished.

Here is where we learned five more lessons:

Lesson 3: *The trackers' attention should be on the balloon position at all times.* We had to run a newspaper article entitled "Lost, One Really Ugly Balloon." Thirty days later we retrieved the balloon. We got lucky, and some boys riding dirt bikes in a pasture 17 miles northwest of Perryton found the remains and called us.

Lesson 4: *Use better packaging than Styrofoam™ picnic coolers.* On the way down, the payload hit a boulder and the contents inside shot upward, bursting through the lid. The crystal came out of the socket, causing the 2-watt 146.52-MHz transmitter to cease operation. Ironically, even after 30 days in the rain and sun the transmitter worked when another crystal was plugged in!

Incidentally, chase team members had driven within a mile and a half of the parachute and payload looking for it. The videotape of the launch shows someone grabbing the balloon with a pinch grip to prevent the balloon from hitting a vehicle.

Lesson 5: *Handle balloons gently.* The Kaysam balloon has an initial thickness of 0.0035 inch and at burst altitude it will be approximately 0.0001 inch. We wear soft brown cotton or surgical gloves while working with the balloon to protect the fragile surface.

Lesson 6: *Have plenty of line between sections of the payload.* We often use six feet or more to prevent tangling, as apparently happened in the second flight. A payload without an open parachute can hit the ground at over 100 mph! This leads us to the next lesson. . . .

Lesson 7: *Use a hoop on the parachute lines to help keep the lines from tangling and the chute open.*

At about this time all of the balloon enthusiasts were working on the same basic problems: payload components, selection of power sources, tracking, pay-

(Continued on page 72)

Photo B. Filling the balloon is a group effort—one person to control the helium, one to be sure the balloon doesn't twist, and at least two to keep the balloon upright.

Photo C. Tying off the balloon is an art, and it takes more than one person to do it.

Bandswitching for Multi-band Rover Contesting

Microwave contesting presents many unique challenges. In this article N5AC covers how he met his challenges.

By Steve Hicks,* N5AC

In a microwave contest, there are usually two key types of participants: the fixed stations and the rovers. The fixed stations operate from their homes, a club station, or perhaps even a portable location, while the rovers drive from grid square to grid square making contacts. Without a tower in the yard and with a love of driving, I decided early on that roving was for me. However, constructing a rover station presents a unique set of challenges.

Anyone who has been roving with a microwave station during a contest will tell you there are so many little things you have get right, that anything you can do to simplify your life is probably worth the effort. All of the difficulties are exacerbated by some contest rules that limit roving operations to two amateurs. Imagine getting a group of transverters, an IF rig, and all of the interconnect hardware to work, mounting antennas on a car (or having to assemble each time you stop on a hill), driving, logging, and navigating for 24–27 hours with only two people!

Since every rover configuration and situation is different (everyone has their own goals and a unique set of radios and configuration preferences), it doesn't make a lot of sense to "cookbook" explain how to construct a rover station. There are, however, some key components that every rover station needs, and the ability to control radios is a key one.

On my first roving trip before constructing any control hardware, I met up with Greg Jurrens, WDØACD, in south Texas. We had several beams and were operating on 6 meters, 2 meters, 440 MHz, and 1296 MHz, all with commercial amateur gear. Our beams were long and required assembly; some of the booms were in multiple sections. We had to setup on the side of the road when we were ready to operate. We quickly realized that manually switching the radio to different antennas was a lot of trouble and that there were probably a lot better ways to accomplish this (never mind actually assembling the antennas on the side of the road).

Photo 1. Four surplus 6-pole SMA relays.

After building my first couple of transverters, I was looking for a way to control everything in my truck with only minimal effort required to switch bands. More important, I'm rather absent minded, and I knew that if I didn't make it fairly foolproof, it wouldn't be long before I was transmitting through a preamp or into piece of coax with no attached antenna. The control Holy Grail was a way to push-button switch between all bands. I decided I needed to build something that would control everything and be simple and foolproof. During a contest the obvious time advantage of being able to push-button switch bands made this project a top priority.

Craig, KA5BOU, an avid microwave and weak-signal enthusiast, had met up with me at Microwave Update 2004 and recommended that I buy a few of those 28-volt SMA coax relays that are so readily available and shown in photo 1. If I had a way to control them and switch my IF rig between each of my transverters while I drove down the road, roving would be much easier. I mounted a few beams on the truck (2 meters, 440, 902 and 1296 MHz to start) and mounted all of my transverters on a piece of polypropylene as shown in photo 2, along with a transverter interface box (TIB) from Down East Microwave (http://www.downeastmicrowave.com).

The TIB accomplishes a few key functions. The first is to switch the IF rig between a transverter and an antenna. This allows the IF rig to transmit 144 MHz directly to an antenna when switched off, and when switched on, it redirects the RF to the transverter. This

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is critical if you intend to also use your IF rig as a 2-meter radio during a contest. The TIB also keys the transverter when it sees PTT from the IF rig and the TIB is on (transverter in operation). The final function of the TIB is to provide a negative ALC voltage to the IF rig to turn down the power into the transverter when the transverter is in use. By doing this, a 50-watt IF rig can operate at full power when transmitting directly on 144 MHz, and at reduced power I use 2 watts when transmitting into the transverter without changing any settings on the front panel of the rig.

In my case, I had a number of transverters, so they all needed to be switched to the TIB IF output when they were in use. For this needed a single-pole, multi-throw RF switch.

While I was pondering how to make everything work, I came across an old Fluke 1780A info touch monitor I had bought at a surplus sale. This device is simply a VT100 emulator (a dumb terminal) that also has a capacitive touch screen (see photo 3). The touch screen sends ANSI escape sequences back to the device to which it is connected via RS-232. I decided I would try hooking this up to a BASIC stamp that I had bought to play with. After playing around a little, I quickly realized that I had a powerful combination for controlling my station! I could use the touch screen to select bands that should be connected to the IF rig, and my 28-volt relays would accomplish everything in the background.

I've been asked why I didn't use a computer for the display, and there are two key reasons: My main reason is that my initial thought was to have an "appliance" that is switched on and ready to go, as opposed to something that has to be booted up. The second is that I intended to use this rig primarily for contesting and during roving. With a computer for navigation and logging, I really didn't want to keep two computers running at the same time. Neither of these is a serious objection, and a computer is a very viable alternative to what I've done here.

Rudimentary Control

I started with a simple configuration and used a 2N2222 from the microcontroller to switch a relay between charging a capacitor with 12 volts and then placing it in line with the battery voltage (also 12 volts) to switch the relay. This is a common configuration I have seen used several times, and it uses an initial pulse of a higher voltage to switch a coax relay and then uses the sustained 12 volts to hold the relay in the correct position. This would eliminate the need for a 28-volt supply. I have also seen a number of 12-volt relays, so if you have one of these, the 28-volt circuit would not be necessary. All of this worked beautifully, and I was able to change the position of the coax relay programmatically.

I connected the center pole of the coax relay to the IF rig (actually the transverter output of the TIB), and then each of the positions on the relay were connected to each transverter. This took care of the RF switching, but generally PTT switching is also required, since the transverters also need PTT.

Initially, I was using the PTT output from the radio to directly control the transverters, and I was keying all of the transverters at the same time. This has advantages—namely that the receiver in the transverter is not exposed to the power coupled between the current transmitting antenna and the not-in-use receive antenna. However, it also has a disadvantage:

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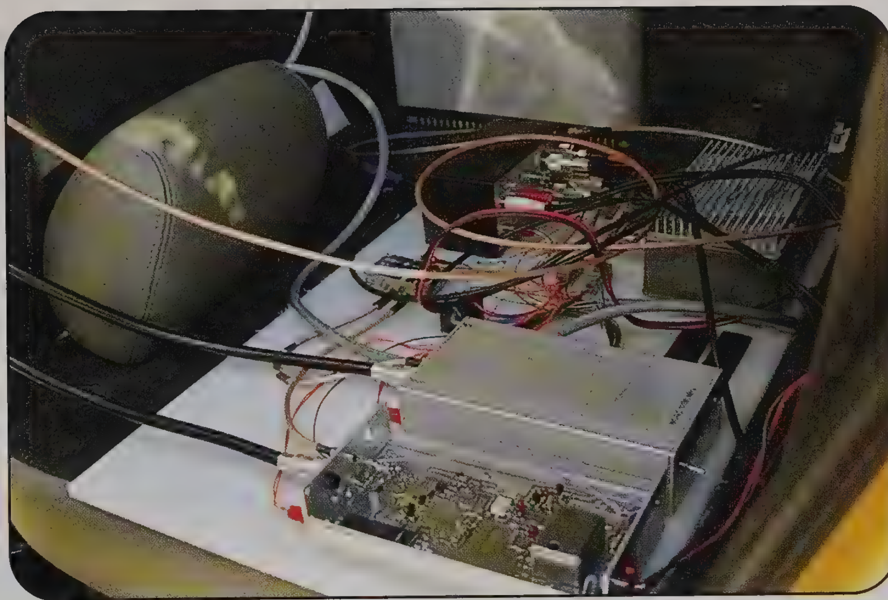

Photo 2. My initial manually switchable transverter arrangement.

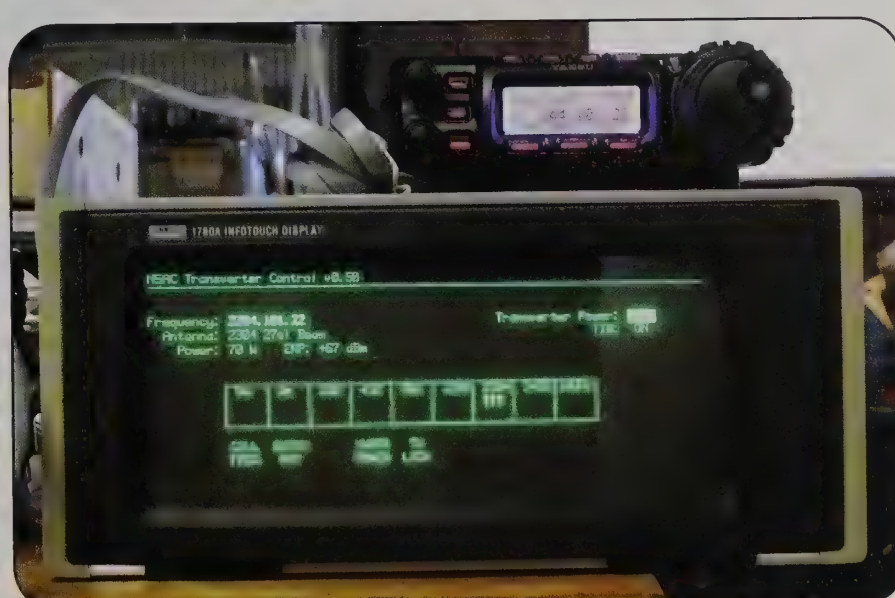

Photo 3. the Fluke 1780A touch-screen terminal under program control.

Connecting Wires to Rocks

One of the most important aspects of the fixed station is grounding. What happens when your station is surrounded by rocky soil or rocks? Here W5EX and W5KTX tell how they solved the problem.

By Larry Higgins,* W5EX, and Joe Jankowski, P.E.,* W5KTX

Have you ever tried to drive an 8-ft. ground into rocky soil—or into solid rock? Many of us have experienced the smarting pain as the hammer handle smacks the hands. Have you seen a ground rod go in for a while, only to make a 180-degree turn and reappear behind you? Maybe it was hilarious at the time, but it is hardly a useful electrical connection!

There is a solution to this problem, but one that is not well known. One of us (J.J.) recently received a short paper from Utah, wherein the authors used a *bentonite* slurry to encase a ground rod, thus expanding the electrical diameter of the rod.[1] References to this article brought us to others, one American,[2] the other Slavic.[3] From this review we learned of the superiority of this natural clay, which contains the mineral montmorillonite, as an adjunct to grounding at sites with poor soil conductivity.

Bentonite

A quick visit to the internet reveals hundreds of references to this widely used material of volcanic origin. It is used in the mining of oil, metal casting, pelletizing, grouting and sealing, and as a base for cosmetics. Aluminum and silicon form the metallic crystalline structure. With water added, ionization of the resident oxides of sodium, potassium, and calcium occurs, forming an alkaline electrolyte. Resistivity falls quite low—~250 ohm-cm at 300% moisture—at which point it swells up to 13 times its dry volume. This striking sponge-like "hygroscopic" property makes the material unique. Unlike ground-enhancing electrolyte solutions, there is no leaching out over time, and thus no replenishment with pricey patented chemicals is required. The material is non-corrosive. It is very sticky when wet and adheres tightly to any adjacent surface.

Let's Try Bentonite and See if it Works!

We examined two west Texas radio sites, the first located on a mesa near Ft. Stockton, the second on a low mountaintop near Sanderson. Both sites have a solid-limestone rocky base. Ft. Stockton has some sandy soil cover sufficient to support several species of cactus, some junipers, and a little grass; the Sanderson site is bare rock. The radio towers are sited on concrete bases; guy wires are attached to rods set in concrete shafts drilled at appropriate angles into solid rock. Average resistivity for gravel, sand stones with little clay or loam is about 10^5 ohm-cm; bedrock, 10^6 ohm-cm.[4]

Photo 1. Mike, KD5FVZ, gouges the trench for the ground system. Note tower base and our tiny radio shack in the background.

The Ft. Stockton grounding system consists of a web of six 5/8-inch copper-clad grounding rods, driven to stop depth, on the average <3.5 ft., connected together with #6 solid-copper

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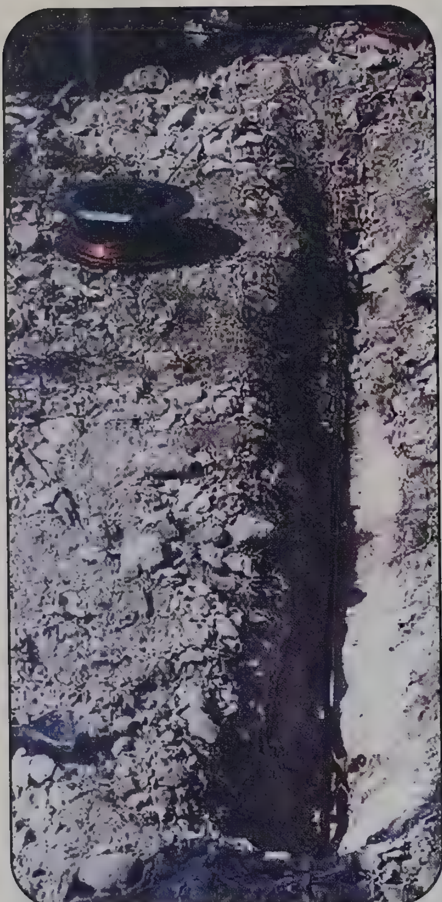

Photo 2. Shallow trench with 8' × 5/8" copper-clad ground rod propped up 4 inches.

Photo 3. Greg, K5DRT, and Mike, KD5FVZ, mix bentonite with water. The hose is connected to a 55-gallon drum that we hauled to the mountaintop.

wire, then brought to a single grounding point within the radio shack. A 170-ft. guyed tower is connected to the loop via a bi-metallic clamp. Where possible, we drove the ground rods tangent to the roots of the juniper bushes in order to maximize rod depth. All rods were separated at a distance >2× their length and surround three sides of a small radio shack.

To create the Sanderson site grounding system we cut an 8" × 8" × 9' trench into the rock (photo 1). One 8' × 5/8" copper-clad steel ground rod was propped 4 inches above the base of the trench (photo 2). We mixed 100 lb. of bentonite powder with 50 gallons of water in a bin and then transferred the slurry into the trench (photo 3). Two 3-inch solar-panel mounts; a steel battery box mounted on a 4-inch pipe, cemented 2 ft. into the ground; and an 80-ft. guyed steel tower were connected to this rod and then to a common grounding point at a small sheet-metal shelter sited near the tower base. The shack is not otherwise grounded—as with attaching stakes, etc.

We borrowed the recently introduced AEMC Model 3731[5] ground-resistance tester for all measurements. These instruments inductively inject a 2.403-kHz signal into the grounding conductor under test and then measure the resulting current. Sixty Hz and extraneous noise are filtered out. The resistance of the ground reduces the resulting return signal current. Since the injected level is known, the resistance to ground follows from Ohm's Law.

Bentonite Really Works!

We measured resistances one month after completing the Sanderson grounding system, and four months after completion of the Ft. Stockton installation (photo 4). There had been a fairly heavy rain at both sites the night before. There were shallow puddles on the access roads to both sites. The exposed bentonite was very soft and mushy. Photos 5A and 5B compare the measured resistance of our grounding system (A) and the existing utility-pole ground wire (B). Table 1 summarizes our findings to date.

Discussion

From the data we achieved an excellent grounding system at both sites. Ground resistance should not exceed 25 ohms for residential or lower powered facilities (NEC Article 250, cited in ref. 4, pp. 2–5); for defense communications 10 ohms is the goal (op. cit.). Because of our extreme vulnerability to lightning, we strive for resistance <1 ohm. As can be seen from the preliminary results in Table 1, our grounds are 10× better than the DOD target values. Furthermore, at a site where driving rods, even for a few feet, is impossible, it would appear that the application of bentonite is very effective. At the more favorable desert environment at Ft. Stockton, multiple ground rods, separated at a distance >2× the length of the rod, seem to be equally usable. We feel that we have achieved an excellent grounding system at both sites.

Grounds at power poles may be less good, because they are often drilled into solid rock. Typically, the utility installs a "butt plate" before setting the pole. This butt plate is connected to the neutral/grounding conductor with AWG 6 solid-copper down lead. This is done at each pole in a distribution line. However, if the poles are set in high-resistivity and/or rocky soil, the effect depends on a large number of poles to achieve the 25 ohms or less acceptable to the utility.

To be fair, we must make further measurements late in the long hot summer, when the earth is drier. We would expect a greater increase in grounding system resistance at the Ft. Stockton site, where-

(Continued on page 76)

First "Back to Back" ARISS Contacts

Students at the Dale High School in Dale, OK, and at the DeGolyer Elementary School in Dallas, TX, made the first scheduled contacts on successive orbits with Bill McArthur, KC5ACR, during Expedition 12 to the International Space Station. Here is the story.

By Keith Pugh,* W5IU

On 7 February 2006 at 1456 UTC, students at Dale High School in Dale, OK, made a successful contact with Bill McArthur on board the ISS. One orbit later, at 1632 UTC, DeGolyer Elementary School in Dallas, TX, also made a successful contact with the ISS. These two schools are approximately 172 miles apart with Dale almost due north of Dallas. Thus, students in both schools were able to hear all of their own contact and most of the other school's contact as well. Much to the dismay of the "Texans," the "Oakies" are now claiming that "Oklahoma is Number One," since the Dale contact was first.

The first "back to back" ARISS QSOs took place on the morning of 7 February 2006. The first of the two QSOs was with the Dale, OK, public schools. Shown here are the Dale High School ninth grade scrince students with teacgher Gary Burkhart (left). (Photo courtesy of Coy Day, N5OK)

The Schools

Dale High School, Dale, OK. Several years ago, while driving home from a radio club meeting, Justin Cochrane asked his grandfather, Ron Cochrane, KD5GEZ, if students at his school could talk to the astronauts as had the students described in the evening's program. Ron replied that they could try. At the time, Justin was still in elementary school, so an application was made to ARISS for the J. D. Jackson Elementary School in Dale, OK, a small rural community about 30 miles east of Oklahoma City, OK.

Between the time of the application and the time of the scheduled contact, Justin moved on to Dale High School. All of the students who directly participated in the contact were Justin's classmates and had moved along with him. Since all of the Dale, OK, schools are located on a common campus, the contact actually became a project of the Dale Public Schools, and 500 of the 700-plus students were able to attend the contact conducted in the gymnasium. Gary Burkhart, a Dale science teacher, coordinated the students' questions and arrangements within the school. Ron Cochrane, a Dale High School graduate, was the radio contact coordinator, and he prepared the crowd by giving an excellent presentation on amateur radio and the space program. Justin and his father were members of the team, along with Ron and yours truly, that installed the antennas and the rest of the station equipment for the contact on the high school roof and in the gymnasium.

A high noise level (that hadn't been present during station check out) plagued the first 30 seconds of the contact. The rest of the 20-degree elevation pass went off without a hitch. All of the students were able to ask at least one of their questions. As usual, Bill McArthur on board the ISS did an excellent job of answering the questions.

Approximately 87 minutes after loss of signal for the Dale contact, the Dale students were able to hear Bill's answers to the DeGolyer students' questions. The original Dale crowd of 500 had to go back to class, but Justin's classmates who asked the Dale questions were able to come back and read the DeGolyer questions for the remaining Dale crowd during the DeGolyer contact. What a unique opportunity!

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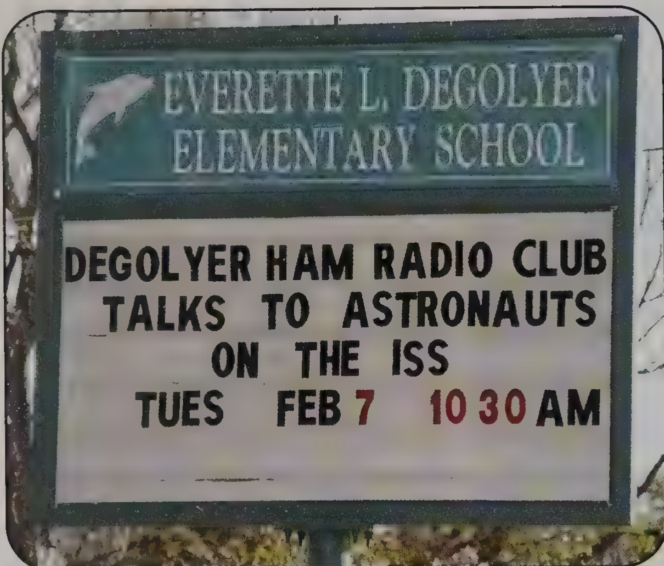
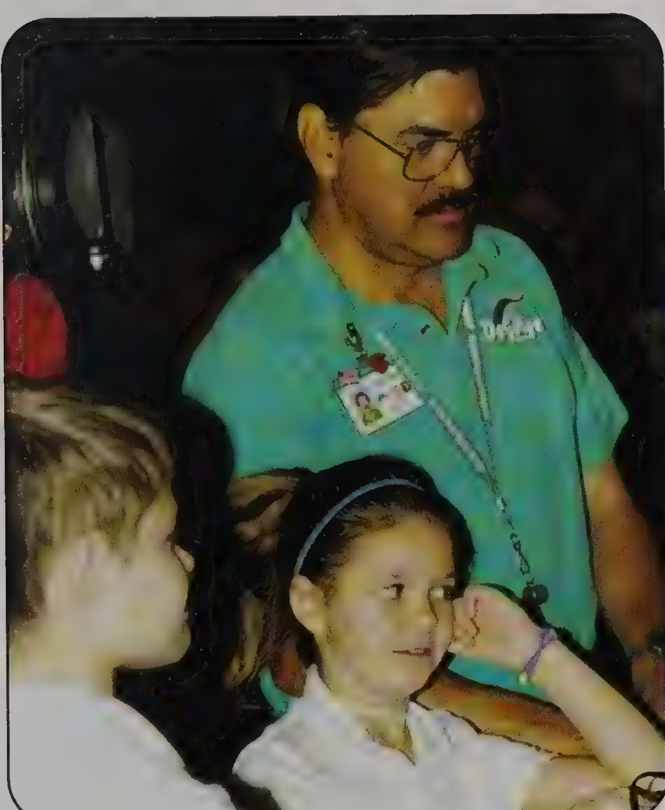


The billboard at DeGolyer Elementary School, in Dallas mades sure that the neighborhood knew what all the fuss (extra traffic, news media vehicles, Dallas Police Department vehicles) was all about. Hams at K5DES prepared to talk directly with Bill McArthur, KC5ACR, the commander of the International Space Station as he flew over the Dallas-Fort Worth metroplex. (Photo © 2006 and used with permission of R. Wayne Day, N5WD)



Richard Aguilar, K5LXM, one of the two sponsors of the DeGolyer Elementary School ham radio club, prepares to record the historic contact between the school and Bill, KC5ACR, operating on board the ISS on February 7, 2006. Aguilar is assisted here by two of the school's students. (Photo © 2006 and used with permission of R. Wayne Day, N5WD)

The event was covered by the local (Dale and Shawnee, OK) and Oklahoma City media. Dale school officials attended, and the ARRL was represented by Coy Day, N5OK, West Gulf Division Director, and John Thomason, WB5SYT, Oklahoma Section Manager. *CQ VHF* was represented by Joe Lynch, N6CL, Editor. ARISS was represented by Keith Pugh, W5IU, Mentor.

E. L. DeGolyer Elementary School, Dallas, TX. The start of the DeGolyer contact can be traced back several years to the formation of the ARRL's "Big Project." DeGolyer Elementary became one of the Big Project Pilot Schools under the guidance of Sanlyn Kent, art teacher, and local resident Jim Haynie, W5JBP, President of the ARRL at the time. DeGolyer Elementary became a very successful Big Project School, and a club station, K5DES, was formed under the guidance of Sanlyn Kent (now KD5LXO). Co-sponsor of the club is Richard Aguilar, K5LXM. One of the initial club projects was to apply for for a school contact with the ISS.

Between the initial application and the scheduled contact

Bob Landrum, W5FKN, operates the push-to-talk switch as students of DeGolyer Elementary School speak with Bill, KC5ACR, on board the ISS on Tuesday, February 7, 2006. Seventeen students were able to speak directly with the commander of the ISS before it moved out of range of the club station, K5DES. (Photo © 2006 and used with permission of R. Wayne Day, N5WD)

time, the DeGolyer Big Project team licensed a number (more than 30) of new amateur radio operators and continued their activity. They even built "throw away" cardboard and aluminum-foil satellite antennas and tested them at the 2002 AMSAT Space Symposium in Fort Worth, TX. Their club station, K5DES, is located in a neat corner of Sanlyn's art classroom and is used regularly.

For this ARISS contact, Sanlyn pulled together a number of current student members and graduates of the DeGolyer Big Project. Questions were submitted by all, and the final team was a mix of current and former members who shared one thing in common: *They all are licensed amateur radio operators.*

Equipment for the contact was drawn from the K5DES club station and supplemented as necessary with additional equipment. The station was set up in the school auditorium so that more people could attend. A team composed of Richard Aguilar, K5LXM; Harold Reasoner, K5SXK; Bob Landrum, W5FKN; and Bob Dickey, AK5V, assembled the required equipment and did the installation on the school roof and in the auditorium. The contact was also televised by closed-circuit television throughout the school.

Not many of the DeGolyer group, other than the installation team, heard the Dale, OK, contact, but the Dale contact did serve as a good checkout of the DeGolyer equipment installation. This was a luxury the Dale group did not have.

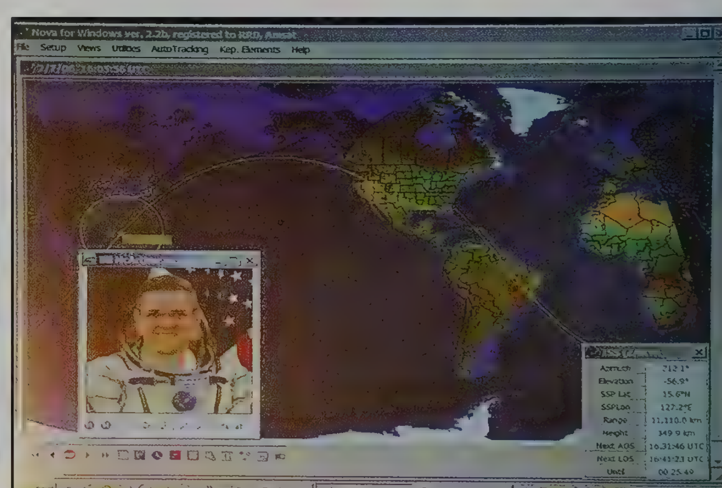
The event was covered by the Dallas media and by a team from the Dallas Independent School District. The ARRL was represented by Jim Haynie, W5JBP, then President of the ARRL, and by Tom Blackwell, N5GAR, North Texas Section Manager. Keith Pugh, W5IU, was the ARISS Mentor for the contact, but was present in spirit only, since he was in Oklahoma for the Dale High School contact.

Summary

Without the willingness of Bill McArthur, these contacts would not have been possible on successive orbits. As a matter of fact, this same type of operation has now been done twice more during Expedition 12, and Bill now has over 35 school contacts to his credit. This record is amplified by his successful achievement of WAS, WAC, and DXCC during Expedition 12. Many other contacts were made during the hunt for these awards, and many other amateur radio operators were thrilled to make contact with an astronaut.

While the "back to back" contacts were neat, the real reward is the successful completion of two more school contacts, and the "sparks" that these contacts ignite in the minds of our youth. ■

Bob Landrum, W5FKN, and DeGolyer students eagerly await Acquisition of Signal (AOS) for the start of the contact while looking at the map. (Photo used with permission of Lisa Leon of Dallas ISD)



ISS track on a world map by Nova for Windows with an inset picture of Bill McArthur. (Photo used with permission of Lisa Leon of Dallas ISD)

Ionospheric Phenomena on Other Planets

Information obtained recently by various space probes points out ionospheric phenomena on other planets similar to those found in Earth's E-region. Further exploration in this area would help expand our knowledge of terrestrial modes of VHF propagation on Earth. WB2AMU explains . . .

By Ken Neubeck,* WB2AMU

The saying "we are not alone" has often been used in the past to describe the UFO phenomenon. In a way, this phrase is also appropriate to describe the various ionospheric phenomena that result in the different radio propagation modes that we experience on the planet Earth, in particular those which occur in the *E*-region of the ionosphere. Sporadic-*E* propagation is one such propagation mode, and it occurs in force during the respective summer months of the Northern and Southern Hemispheres on the 6-meter band, where signals are efficiently reflected off ion layers in the *E*-region. Another *E*-region phenomenon is the mysterious aurora mode, where radio signals are reflected off the active aurora in a backscatter mode and have tremendous distortion. Radio amateurs get to experience these really interesting modes by operating on the VHF bands at the right time.

It is so easy for hams to think that aurora conditions and sporadic-*E* propagation are unique only to Earth. However, as recent results obtained by various space probes have pointed out, it is apparent that many of the other planets in our solar system have similar physical phenomena. These include the aurora phenomenon as well as the existence of metallic-ion layers in the atmosphere.

Such an area of exploration would be extremely helpful in increasing our knowledge base of terrestrial modes of VHF propagation on Earth, such as aurora and sporadic-*E*. While other planets have noticeable differences in the reasons why these phenomena occur, the understanding of these differences and why they exist will ultimately lead to a clearer understanding of the behavior of aurora and sporadic-*E* propagation modes on Earth.

In this article we will concentrate on the above two *E*-region propagation modes on Earth and explore the form in which they exist on other planets in our solar system. The formal, structured ionosphere that exists on Earth—where there is a clear distinction between layers (known as the *D, E,* and *F* region)—may or may not exist in a similar manner on other planets. Although the presence of a metallic-ion layer (which is what sporadic-*E* is on Earth) and an aurora-type phenomenon has been noted in the ionosphere of other planets, at this time no determination of different layers has been made.

Discovery of Metallic-Ion Layers on Other Planets

In recent years a number of space probes have been launched that led to the discovery of similar phenomena on other planets. These have been documented in a number of recent papers. Table 1 summarizes these discoveries.

The planet Jupiter is a case in point, with data beginning collected as early as 1981 (reference 1). Over the years, observations of its ionosphere were made by the Voyager 2, Pioneer, and Galileo probes. The initial data suggested some very interesting phenomena in the area of metallic ions. It pointed to the existence of a low-altitude ionospheric layer with a peak electron density of 10^4 per cubic centimeter in the area of 350 to 450 km above Jupiter's surface. Data from a sub-

Planet	Presence of Aurora	Metallic-Ion Layers	Presence of Magnetic Field	Axis of Rotation
Mercury	No	No	No	0°
Venus	Yes	No	No	177°
Earth	Yes	Yes	Yes	23.45°
Mars	Yes	Yes	No	25°
Jupiter	Yes	Yes	Yes	3°
Saturn	Yes	Yes	Yes	26.5°
Uranus	Not known	Not known	Yes	97.5°
Neptune	Yes	Yes	Yes	28.5°
Pluto	Not known	Not known	Yes	120°

Table 1. In recent years a number of space probes have been launched that led to the discovery of ionospheric phenomena on other planets similar to those on Earth. These have been documented in a number of recent papers and are summarized here

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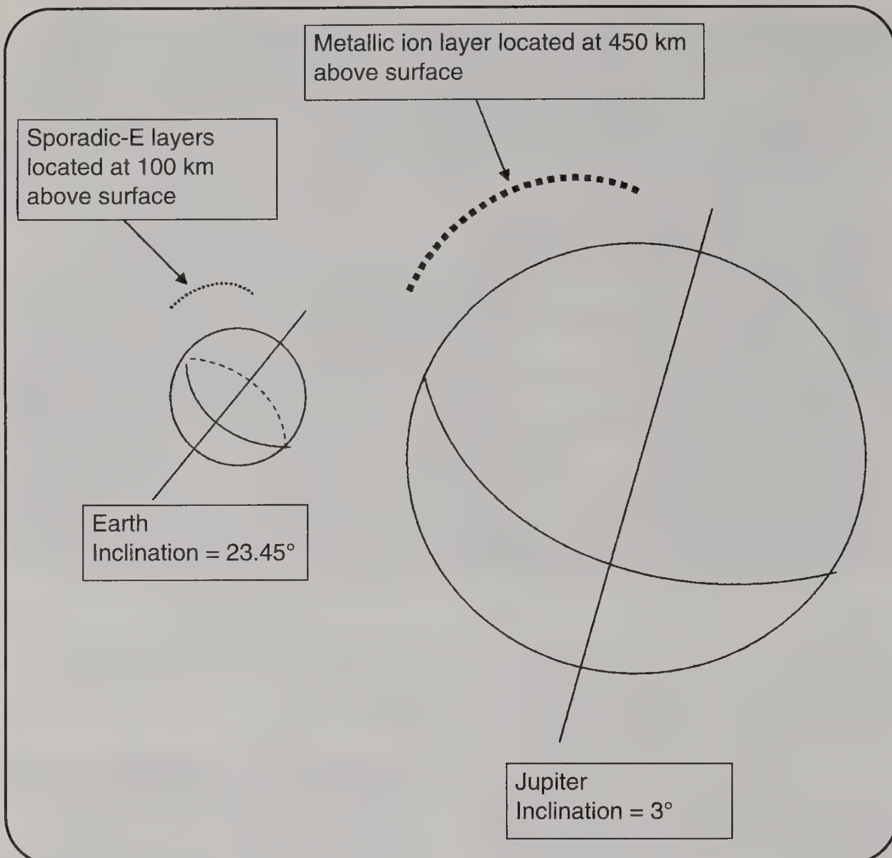

Figure 1. Comparison of Earth and Jupiter. (Note: Shapes are not to scale.)

sequent probe shows that this layer consists of long-lived metallic atomic ions that apparently originated from meteoric influx (reference 2).

For Jupiter, some rough calculations have been made which show that approximately 20,000 tons of meteoric material enter the planet's ionosphere per day, or on the order of 100 to 150 times greater than the influx of material entering Earth's ionosphere.

It is also noted that the diameter of Jupiter is 12 times greater than that of Earth, yet the average height above ground of the metallic layers (400 km for Jupiter vs. 100 km for Earth) is only four times greater. Thus, comparatively speaking, the metallic-ion layers are closer to the surface of Jupiter (see figure 1).

Voyager 2 data pointed out the existence of sharp layers of electrons, also on the order of 10^4 per cubic centimeter density (reference 3), in the ionosphere of the planet Neptune at around 700 km above its surface. The study notes the similarity of these layers to the *E* layer on Earth. The study also declares the importance of magnetic field in layer formation, as well as determining that magnesium metallic ions are the most likely metal to be found in the layers on Neptune.

Indeed, the discovery of metallic layers is not confined to just planets in the solar system. They also have been detected on some of the moons of these planets, such as Titan, the moon of Saturn. Ions of iron, magnesium, and silicon have been discovered on this moon at a 650-km height range above the surface, again in the neighborhood of 10^4 per cubic centimeter density range (reference 4).

It appears that the process for creating metallic ions is different on other planets than it is for Earth. It is well known that meteor ablation does not result in direct formation of metallic-ion (sporadic-*E* propagation) layers on Earth. VHF hams are well aware of meteor scatter, where localized ionization from meteor particles can occur. However, for sporadic-*E* layer formation there is a rather complex process in which metal atoms such as iron and magnesium fall to 90 km above the Earth, where many of the particles recombine with oxygen ions (in a charge exchange) and actually are transported to higher altitudes (reference 5).

For some of the planets, though, the process is different from that which occurs on Earth. For example, one paper (reference 6) notes, "For a heavy planet like Jupiter, far from the sun, impact ionization of ablated neutral atoms by impacts with molecules becomes a prominent source of ionization due to the gravitational acceleration to high incident speeds." Thus, this "instant ionization" is in contrast to the complicated process that takes place on Earth. The charge exchange in Jupiter's atmosphere takes place immediately between the ablated metal atoms with resident hydrogen ions. Figure 2 compares the processes on Earth and on Jupiter.

The paper also notes even more differences with regard to other planets: "Within the carbon dioxide atmosphere of Mars (and possibly Venus), photoionization is important in determining the ion density." Since the process of metallic-layer ionization is more direct and immediate on other planets, it can be speculated that there may be less of a possibility of a seasonal pattern as observed in the sporadic-*E* phenomenon on Earth.

Another paper (reference 7) speculates that a layer of magnesium ions should exist at around a height of 70 km for the planet Mars, with the same density level as listed before. The study also notes that the low ultraviolet absorption of the atmosphere on Mars makes it an excellent canvas for studying meteoric ablation and the formation of metallic-ion layers.

Discovery of Aurora on Other Planets

Aurora activity, prevalent in the higher latitudes of Earth, is the manifestation of the interaction between electrically charged particles from the sun and the neutral upper atmosphere as they precipitate along magnetic-field lines. There are not only visual displays associated with aurora; aurora also affects radio waves in the VHF region. Particularly during high periods of enhanced geomagnetic activity, the aurora region extends into the lower latitude, where backscatter aurora contacts are made on the 6-meter band and occasionally on 2 meters. However, from recent studies based on data collected from instrumentation on probes, it is apparent that the aurora phenomenon is not unique to Earth. Indeed, it is seen on several other planets in the solar system!

One recent paper (reference 8) states that auroral activity has been found on all four giant planets possessing a magnetic

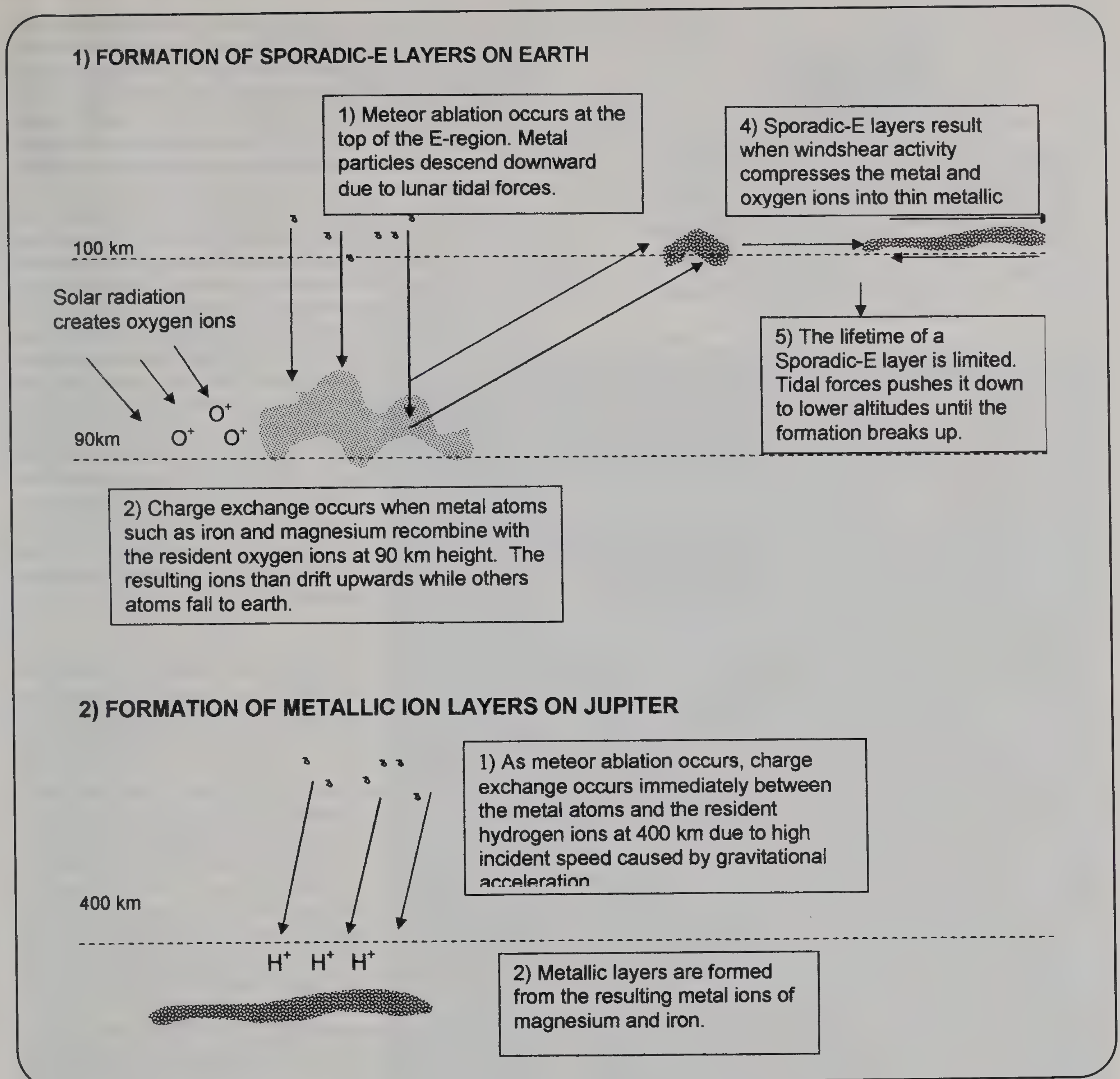

Figure 2. The differences in the process of how metallic-ion layers are formed on Earth and Jupiter. The process that occurs on Earth is an indirect, or two-step, process, whereas conditions on Jupiter allow for a more direct conversion, or "instant ionization, process when meteor ablation occurs.

field (Jupiter, Saturn, Uranus, and Neptune), and also on planets such as Venus and Mars, which do not have a planetary magnetic field that seems to be caused by high-energy electrons. The Mars Express probe, using an ultraviolet spectrometer, has determined that Mars' aurora is quite unique with regard to that of the other planets in that the aurora is highly concentrated and controlled by magnetic-field anomalies in the Martian crust. This is in contrast to the type of auroras that are centered around the geomagnetic poles on other planets.

Studies of the larger planets that have magnetic fields, Saturn and Jupiter, have shown some interesting differences between the two (reference 9). Saturn's aurora seems to respond to strong solar-wind conditions, in contrast to Jupiter. However, in contrast to Earth, where the solar-wind dynamic pressure and electric field are major factors, these two factors are of lesser impact on aurora formation on Saturn.

Relevance to Phenomena Experienced on Earth

It is truly amazing to think that there are phenomena similar to sporadic-*E* and aurora appearing on several other planets in the solar system! By studying the

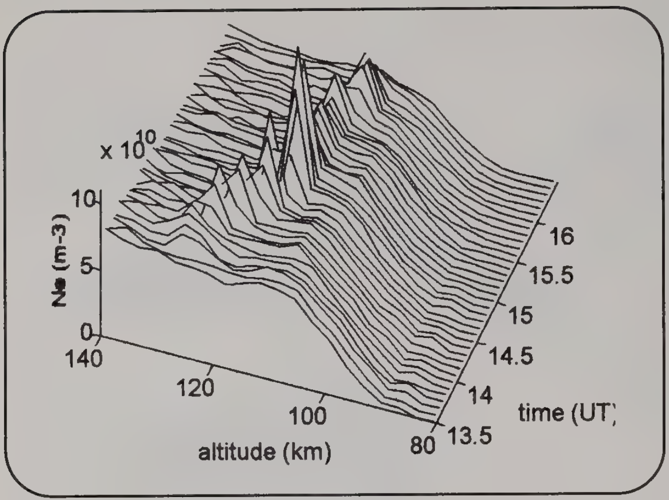

Figure 3. An EISCAT radar plot of a sporadic-E formation on Earth that is traveling downward in altitude due to the forces of the lunar tide. (Courtesy of S. Kirkwood)

behavior of similar phenomena on other planets, what can we learn about these phenomena on Earth? We will break this down into two areas: metallic-ion layers (*E* layer) and aurora.

I. Metallic-Ion Layers

1. Many aspects of the sporadic-*E* phenomenon on Earth are not unique! From the determination of specific ion types that are in the metallic-ion layers on Mars, Jupiter, and Neptune, and comparing these to Earth, it would seem that meteor debris is the primary source of neutral atomic metal material that eventually becomes metallic ions in the ionosphere of these planets. The most common metallic ions detected are iron and magnesium, with lesser amounts of sodium and silicon.

2. It would be of interest in the future to see if there are different chemical processes in the planet atmospheres that may produce more of one type of metallic ion than another. For example, could there be more iron ions than magnesium ions for one planet, with the situation reversed for another planet because of the different chemical and recombination processes in the ionosphere?

3. The effect of the geomagnetic field appears to a major factor of sporadic-*E* development on Earth as compared to other planets. Essentially, there are three zones on Earth—aurora, temperate, and equatorial—with the sporadic-*E* formation process being different in each due to the geomagnetic-field lines (see reference 5). The differences can be observed on the VHF bands as well.

4. The most unique aspect of sporadic-*E* on Earth is the existence of the strong summer sporadic-*E* season. This is directly related to the Earth's 23.45-degree tilt of the axis of rotation and effects of solar radiation on metallic-ion formation in the *E*-region. For a planet such as Jupiter, which only has a 3-degree tilt, the effects of seasons on the metallic-ion layer may not be present or as significant (see figure 1). By the way, when talking about a summer season on Jupiter as compared to Earth, the season is much longer in duration on Jupiter, as Jupiter's rotation around the sun takes over 11 Earth-years!

5. Tidal forces have a major effect on sporadic-*E* and are of major consequence in the lifetime of a sporadic-*E* formation. On Earth, the force of gravity drives the sporadic-*E* formation downward from the area of 120 km to 90 km, where it breaks up, with some ions fall to Earth and others traveling upward toward the *E* and *F* regions (see figure 3). The duration of a single sporadic-*E* formation on Earth rarely exceeds a continuous 10 hours and is almost never more than one day. On a planet such as Jupiter, which has a gravitational force that is much greater than that of Earth, it may be that a metallic layer would have an even shorter duration.

6. The larger amount of meteoric debris associated with Jupiter may result in denser metallic formations. Thus, if radio communications were feasible on this planet, the metallic-ion layers could probably consistently reflect radio waves at the extreme VHF frequencies (e.g.., 2 meters and 220 MHz)!

7. The existence of metallic-ion layers on several other planets besides Earth, as well as the direct conversion of meteor ablation into ion layers on the planet Jupiter, suggests that metallic ions are the primarily component of sporadic-*E* on Earth. This may rule out the idea that thunderstorms are the direct cause of sporadic-*E*. There is still the belief that thunderstorms may have an indirect effect on Earth's sporadic-*E* events by perhaps intensifying these layers (reference 10). Also, whereas the process of charge exchange is more direct with other planets, the process on Earth leading to the creation of sporadic-*E* formation is more complex, involving recombination processes with existing ions at certain heights in the ionosphere.

II. Aurora

1. As in the case of sporadic-*E* on Earth, the geomagnetic field plays a major part in aurora formation on Earth and several of the major planets. However, it is interesting to note that aurora exists on planets such as Venus, where there is no magnetic field.

2. Solar wind is the mechanism that drives the formation of aurora on all of the planets that experience this phenomenon. Just as in the case of Earth, solar activity (such as flares) that is geo-effective toward the poles of these planets would seem to cause increased aurora activity and extension into lower latitudes. In fact, some solar eruptions may affect some planets, depending on the geo-effective positioning and also the strength of the eruptions. It would be of interest to see the difference in the amount of aurora activity for Earth and for planets that are farther away from the sun.

3. It also would be interesting to see which planet experiences the most aurora activity and from that determine the ideal conditions (other than the impact of the solar wind) that would allow for more aurora on a planet.

4. Based on initial findings, it would be interesting to see if other planets besides Earth have the type of aurora that could reflect radio waves. A major component of the radio aurora (where signals can be reflected) on Earth is the aurora's interaction with the geomagnetic field. It is conceivable that while visual aurora is present on most of the planets, the radio aurora may only be present on Earth. Thus, the radio aurora, as opposed to sporadic-*E*, might truly be a unique phenomenon of Earth!

Summary

With respect to understanding sporadic-*E* and aurora phenomena on Earth, it will help to take a look at the "big picture," or the solar system itself. By looking at the various parameters of the planets of the solar system, information can be gleaned from each of the planets, while realizing the differences in sev-

eral of the parameters (inclination of axis, rotation period, etc.). It is truly interesting to note that neither the existence of the aurora nor thin metallic layers are unique to Earth. They exist on several other planets as well in a somewhat similar fashion.

Indeed, many questions regarding the two phenomena on Earth appear to be answered by looking at the bigger picture. Perhaps the major question about sporadic-*E* that remains is in regard to its unique seasonal pattern—a major peak of activity during the summer, a minor peak during the winter, and significant voids during the equinox period. Yet from what has been observed for all planets, meteoric flux is fairly consistent.

Thus, part of the answer for Earth has to be connected to the ionization process that takes place at 90 km, which is more prevalent for those geographic areas that are experiencing summer. As metallic ions have been detected throughout the *E* region throughout the year by numerous rocket launches, it can be speculated that the reason for the voids is most likely not due to a lack of metallic-ion availability, but rather due to other factors that are unique to Earth (as compared with other planets). These factors may be associated with Earth's geomagnetic field and/or prevailing winds in the *E* region that cause significant changes in this region during the equinox period when significantly less sporadic-*E* formations occur.

Future space probes may provide more data to help in this area. The data may relate to the area of *F*-layer based phenomena such as TEP (transequatorial propagation) and *F2*-layer propagation. However, with Earth being the only planet in the solar system that has significant oxygen components in the atmosphere, the likelihood of a phenomenon identical to *F*-layer propagation is slim, since that involves solar energizing of the oxygen molecules.

I would like to thank Dr. Sheila Kirkwood, Dr. Joseph Grebowsky, and Dr. Jane Fox for providing me with background material that helped me in writing this article. I would also like to thank Dr. Jerry Hinshaw, KE7DJD, for reviewing my article prior to publication. ■

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Historical Trends of the CQ VHF Contest

The reasons for the ups and downs of VHF contesting are elusive and hard to determine. Here W9GKA analyzes the CQ VHF Contest to determine what role it plays in the overall picture of VHF contesting history.

By Kevin Kaufhold,* W9GKA

In an attempt to find out what has been causing the massive fluctuations in VHF contest activity, historical data on the ARRL VHF contests has been collected over the last several years. This article extends the effort to the CQ WW VHF Contest, and finds some interesting trends in the data and historical information.

History of the CQ VHF/WPX Contests

CQ magazine has sponsored VHF contests in two distinct eras: 1956 to 1966, and 1985 to the present. In the first era, the *CQ* contests were marked by an extraordinary amount of innovation. Counties and county equivalents were used as multipliers some 25 years before the League adopted the Maidenhead grid squares as sub-section multipliers. Operator effort was awarded through a multiplier for the number of hours of operation in which at least one contact was made. No corresponding item has ever been incorporated into the ARRL events. A power multiplier was established 30 years before the League moved to high- and low-power distinctions in the multi-op categories and 40 years before the appearance of the SOLP (Single Operator, Low Power) category. A one-day, 12-hour contest was experimented with 30 years before the four-hour long VHF Sprints were implemented in 1983. As early as 1960, a CQ Century Club award was given for anyone having a certain number of contacts on the VHF bands. This award predated the VHF UHF Century Club (VUCC) by some 23 years.

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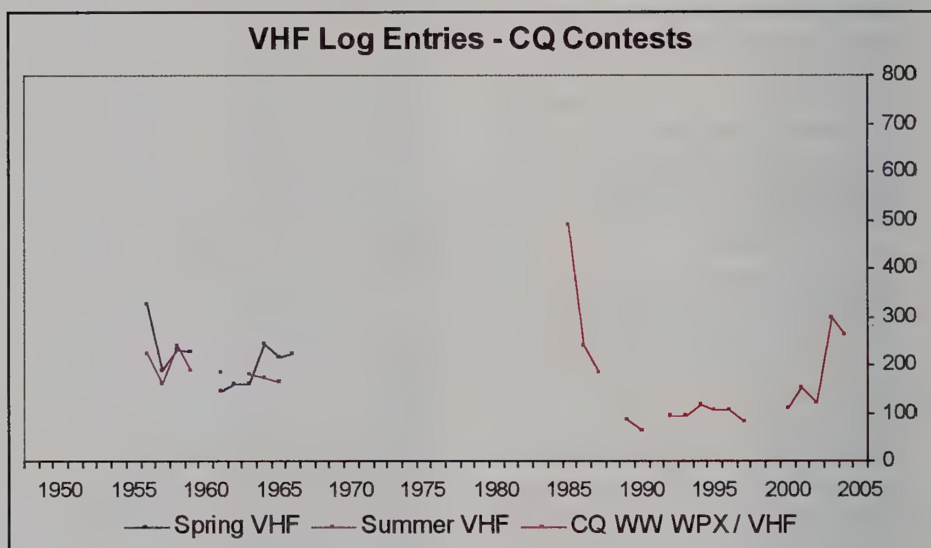

Figure 1. Log data for the CQ VHF contests in the 1956–1966 and 1985-to-the-present time frames.

This innovative style has continued into more recent times. In 1985, the WPX program was used as the basis for multipliers, and the contest was then styled as the CQ WW WPX VHF Contest. A CW incentive was awarded from 1992 through 1999, which is something that would still be of relevance today. In 2000, Gene Zimmerman, W3ZZ (then the newly installed CQ VHF contest coordinator), extensively revamped the contest to 6 and 2 meters only. This concentration on only the two lower VHF bands is in sharp contrast to the all-inclusive nature of the three main ARRL VHF contests.

Contest log data for the CQ VHF contests in both eras is shown in figure 1. Missing data in the graph is due to the following: no results are believed to have been published for spring 1960, 1998, and 1999; results were published but have not yet been located for summer 1966 and 1988; and no contests were conducted in summer 1960, 1962, and 1991. The author would be grateful to anyone who can supply information or published results for any of these.

Two annual events generally were con-

ducted in the first era, while the focus has been on one July contest in the current period. In addition to these contests, *CQ* conducted a YL VHF contest between 1961 and 1964, as well being involved to a certain degree with the "VHF Amateur" contest in 1962 and 1963. In the late 1990s, *CQ* even attempted an "Internet" 6-meter contest that ran concurrently with the July VHF contest, experimented with VHF activity weekends, and also conducted VHF foxhunting activities.

Individual Rules Changes

When viewing only ARRL data, the current consensus among many observers is that individual rules changes have not greatly influenced the number of contest log entries. For instance, the adoption of grid squares and the development of the VUCC program by the League was warmly received and quickly accepted within the VHF community, but log entry data did not dramatically jump in response. In general, ARRL rules changes have had a far greater impact on contest point totals than on overall participation levels.

In looking at the CQ VHF, the same general pattern is evident. The *CQ* contests had significant rules changes in both eras, and yet contest participation and log activity did not dramatically and quickly change (with two possible exceptions, noted below). Some of these rules revisions included the addition of hours of operation and power as multipliers in 1958. Thereafter, changes included deleting power multipliers for multi-band operations; dropping multi-ops altogether in the summer of 1963; starting the club competition in the spring of 1963; and moving to single-band-only competition in 1963.

The current era also has experienced major, if not radical, changes: modifications were made to the prefix and grid multipliers in both 1992 and 1995; the event was changed from a six-band run in 1985 to an all-band contest in 1995, and then to a two-band contest in 2000. Changes in both eras generated huge increases in point totals in all categories of operation, but in general did not measurably change log entry statistics.

Even when rules changes were made with the specific intent of boosting participation, things did not quite work out as planned. A separate 12-hour contest was attempted in March 1963 (styled as the VHF Amateur Contest), and this event enjoyed tremendous success. It was

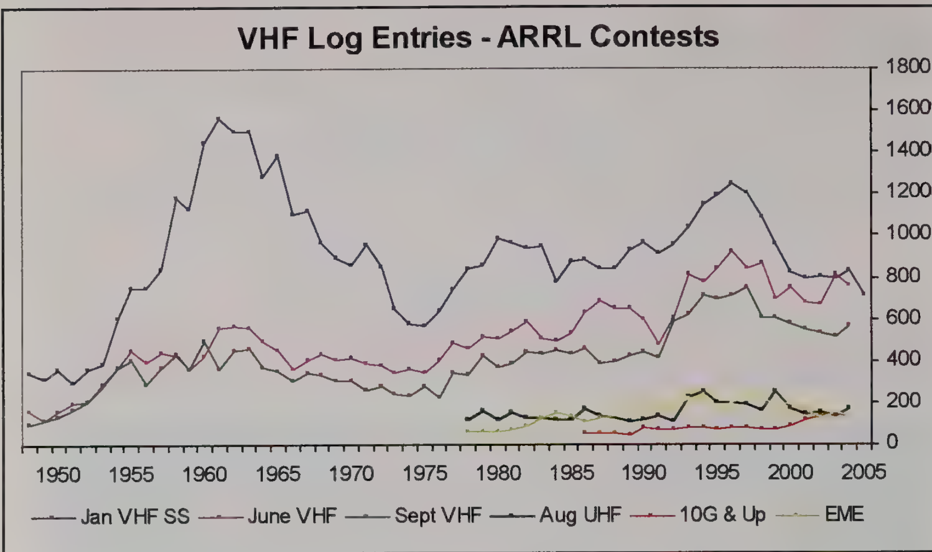

Figure 2. Log data for the ARRL VHF contests from 1950 through 2005.

hoped that a change to the 12-hour format in 1965 would produce a similar surge in operator interest. When the one-day, 12-hour affair was trotted out on short notice for summer 1965, however, the results were anything but exciting. Chaos and confusion existed among the contestants, and total log entries declined slightly from the year before. The 12-hour option was then abandoned for future summer events, but was next attempted in the spring of 1966. Log entries did not measurably increase then, either.

A one-time boost in contest activity did occur at the beginning of the second era of the CQ VHF contests, however. A certificate was issued to every single contestant in 1985, and the event was considered an initial success. The next year, the rules moved to a more traditional awards format, and this resulted in a massive reduction in log entries having smaller contact and point totals. For a further analysis of the impact of the special certificate upon the 1985 and 1986 contests, see *CQ*, July 1987, p. 11. This one-time effect on log submissions is similar to what the League experienced when it first issued participation pins in the 1993 August UHF. Log entries exploded from 108 submissions in 1992 to 223 logs in 1993. After peaking at 249 logs in 1994, log entries in the UHF contest thereafter resumed a downward course.

The most recent rules change, in 2000, to that of a two-band contest may also be impacting log entries. There has been a pronounced increase in participant levels since the new format was adopted. This is especially interesting when compared to the ARRL contests, which have gone through a down-trend and possible stabilization since 1996. Why has this one rules change evidently mattered when so many other changes have not mattered at all? Perhaps it is due to a basic redefinition of the nature of the contest, itself. The latest version of the CQ VHF contest is

truly different from any of its predecessors and all of the ARRL VHF tests. The lower two-band concept draws on VHF contesting history in both *CQ* and ARRL events, being reminiscent of strong and wildly popular single-band runs that occurred on 6 and 2 meters in the 1960s. It is also comparable to many current HF domestic contests, with concentrations on only one or a few bands (10 meters, 160 meters, HF Sweeps at solar minima, etc.). To this extent, the current version of the CQ VHF may be filling a niche in the national VHF scene that has been missing up until this time.

Contesting Peaks

Two distinct and definite peaks in contest log activity have occurred in the ARRL VHF contests (see figure 2).

The explosion of contest activity in the 1960s centered on the January VHF Sweepstakes, while both the June and September VHF QSO Parties had a much smaller impact. The Sweepstakes was a club competition event, while during that time period the other two QSO Parties only included individual and multi-op entrants. This made the January VHF the one big contest of the year. The situation changed substantially beginning in the mid-1970s, with the June and September contests becoming comparatively more popular as interest from individual operators increased. The second contesting peak in 1996 shows more of a cyclical pattern in all three of the main ARRL contests.

The cyclical nature of the number of contest log entries has been traced to major regulatory changes occurring over the years. Several changes in regulations produced a tremendous influx of Novices and Technicians in the 1950s, as well as a flood of Technicians in the 1990s. VHF contest activity boomed in those time frames. VHF club activity, technological changes, demographic patterns, and even sociological and economic factors are also thought to have varying roles in the dramatic shifts in contest activity.

Amazingly, in both eras, the *CQ* contests do not appear to have peaked in conjuntion with spikes in the number of amateus joining the ranks, as the main ARRL VHF contests have done. Even with the great surge of amateurs coming onto the VHF bands in both the early 1960s as well as the early to mid 1990s, the CQ VHF did not increase its overall log entries in either era (although some of the log entry results on the CQ VHF were never published and the contest ran in only limited time frames, so it's difficult to make a definite conclusion in this regard). The apparent lack of peaks in the CQ VHF activity could be due to the radically changing nature of the contests during both critical time periods. The CQ VHF was going through self-described "transitional periods" in the early 1960s, while it came to a complete standstill in 1991, with a gradual revitalization occurring only thereafter.

The absence of a contesting peak could have another explanation, at least in the 1960s: Only the January VHF SS experienced a tremendous spike in operator interest. With no clubs being involved in the CQ WW VHF until 1963, the *CQ* contests more closely resembled the June and September VHF QSO Parties in style. In the late 1950s, new hams flocked to the clubs, as they were then at the very hub of amateur activity. With only individual participation in the *CQ* contests as well as in the VHF QSO Parties, non-club events had much lower support and activity levels than the VHF Sweeps. This does not explain the absence of a peak in the 1990 era CQ VHF data, however. With the major ARRL non-club contests showing definite upswings in log submissions in the early 1990s, the lack of a similar pattern in the CQ WPX/VHF suggests that structural problems in the *CQ* contest itself may have overridden or effectively eliminated any increased activity stemming from new licensees.

Year	Call	2 m Qs	Asia Logs	EU Logs	% Logs
2002	E21DKD	587	19	—	3.2%
	F6IFR	420	—	7	1.7%
2003	HS4NLW	514	21	—	4.1%
	OK1KIM	451	—	28	6.2%
2004	E21DKD	592	41	—	6.9%
	OK1KIM	527	—	21	4.0%

Table 1. The top scorers in Asia and Europe in the last three CQ VHF contests.

Contest Administration

Many observers believe there is little or no relationship between ARRL administrative efforts and variations in contest log activity. Some of the more recent activities of the League (i.e., deletion of the line scores from *QST;* contest robot) have drawn jeers from contesters, while many of the League's innovations (the contest area of the ARRL website; LoTW [Logbook of the World]) have won applause from the proverbial peanut gallery. None of the League's efforts, however, have affected VHF contest activity to any great and measurable extent.

However, when the general styles of ARRL and *CQ* contest administrations are more closely examined and compared, some interesting trends emerge. *CQ's* handling of its VHF contests may involve unique and interesting experiments, but the execution of its events has been anything but routine in either contesting era. Much of the problem with *CQ* contest administrative efforts in the past simply may have been due to the *CQ* VHF columnist having a dual role which included directorship of the CQ VHF contests. Whenever the VHF column editor became busy on other matters, the contest suffered as a result. The contest structure at *CQ* just may have expected too much from one person, as writing a VHF column is time consuming in itself. Adding contest administrative duties to the "job" requirements of the column writer may have doomed the VHF contest to a chaotic existence for many years.

This is not to criticize past VHF column writers at *CQ*. Indeed, the column editors all have brought their own unique flare and style to a time-intensive, volunteer position: Sam Harris, W1FZJ, pioneered EME activities while writing the *CQ* column in the late 1950s; Bob Brown, K2ZSQ, merged an entirely separate VHF magazine into *CQ* in the early 1960s; Steve Katz, WB2WIK, reinvigorated the post in the 1980s, some 15 years after the column last appeared in the late 1960s. Furthermore, Joe Lynch, N6CL, not only edited the VHF column in *CQ* starting in August 1991, he went on to become the editor of *CQ VHF* magazine in 2002, when it was brought out again after it had ceased publication and been incorporated into *CQ* magazine for three years. In its initial four years of publication, *CQ VHF* magazine was edited by Rich Moseson, W2VU, the present editor of *CQ* magazine.

Contrast this situation at *CQ* with the ARRL. The League has consistently and methodically produced high-caliber VHF contests since the post-WW II period (and for many years before, when VHF Marathons and U.H.F. Relays were also included).

The VHF contests at the League and the "World Above 50 MHz" column in *QST* are handled by different people. This consistency of contest style and deep support from the contesting community comes at a large cost: the ARRL events are very slow to change, even in the face of stagnant to declining participation levels. The difficulty in quickly adapting the League's rules structure to changing circumstances may be a big reason why the ARRL contests are comprised of well-established participants. The preponderance of older, established contestants could be the distinct result of new contestants being unwilling or unable to compete against an entrenched group of operators who can repeatedly win with a fixed rules set.

Conversely, the *CQ* style of contest, with its unique rules, certainly attracts new participants. However, in the past, some burn-out has occurred in entrants who grew frustrated with the less-than-ideal execution of the formatand the continual changes in the rules structure.

Because the ARRL and *CQ* have such dramatically different contest management styles, reviewing both administrations side-by-side may be something of an "apples to oranges" comparison. Arguably, the ARRL may have a stifling amount of predictability, while historically *CQ* has suffered from a lack of predictability. To the credit of each of the contest administrations, the ARRL is attempting to bring more systematic change to its process, and *CQ*'s one annual VHF contest (as well as its current VHF column) has now run longer than all of its trailblazing VHF events and activities in the first era of VHF contesting. In addition, with the CQ VHF contest now having a separate contest coordinator (initially Gene Zimmerman, W3ZZ, and now John Lindholm, W1XX), the contest is running smoother than in prior years, while the "VHF Plus" column in *CQ* magazine has been a great addition to the VHF community over the 14 years that Joe Lynch, N6CL, has been its editor.

CQ VHF Contest Participation Levels

What accounts for the sizable difference in log entries between the CQ VHF Ccontest and the three big ARRL VHF contests? Certainly, many League members and affiliated clubs favor the ARRL events. The League's events also have something of a strategic advantage, in that they exclusively have occupied the same contest weekend for many years. This is in contrast to the CQ VHF contest, which is squeezed in between the ARRL VHF events and also has to contend with numerous VHF contests in Europe that occur around the same time.

A major reason for the log entry difference, however, could also be that a far lower percentage of stations that are generally active in contests are entering the CQ VHF contest than the ARRL events. This belief is tentative, as it is based on only two years of *CQ* log data and four years of ARRL data. The data collected so far, however, infers that the number of worldwide participants in the CQ VHF could be approaching the number of domestic contestants in the June VHF QSO Party, but that far fewer people have submitted log entries in the CQ VHF than in the ARRL VHF contests. This may be the result of the *CQ* contest appealing to many casual VHF operators, especially since 2000, when the format was changed to a two-band event. The ARRL contests have a more intensely competitive grade of operators who possess massive amounts of equipment and antennas all the way through the microwaves bands. These operators are much more likely to submit log entries.

Further, the CQ VHF contest attracts many international participants, whereas most of the ARRL events have specific rules banning DX-to-DX contacts (except for the EME, which is the only League event with an international following). In the last three CQ VHF contests, the top scorers in Asia and Europe made the number of contacts shown in Table 1 (thanks to John Lindholm, W1XX, for the statistics). These are amazing numbers. The top scorers in Europe and Asia had between 420 and 592 contacts on 2 meters. However, there were only 7 to 21 logs submitted from Europe and between 19 to 41 logs submitted from Asia. Thus, only 1.7% to 6.9% of the international stations who worked the world's leaders actually submitted a log entry to *CQ*. Even the 400 to 500 callsigns worked in Europe by the leaders may be small compared to the immense number of contacts made in other European VHF contests. The potential of the CQ VHF to reach an international audience is great and may already be under way.

In all, perhaps 8000 to 9000 stations worldwide have made at least one contact in recent CQ VHF contests (2003– 2004 statistics), and over 4000 callsigns were worked two or more times in a single CQ VHF contest (2003 data). This is comparable to published League information on the June VHF QSO Party, with 4600 to 6100 callsigns worked (2001– 2003 data). While the two sets of data may not be strictly comparable due to differences in master data-base collection and calculation methods, using callsigns worked rather than log entries submitted as the basic measure of "contest activity" changes the various trends of the CQ VHF in a rather dramatic fashion. Indeed, within an international context, the *CQ* event currently may be more popular than any of the domestic ARRL VHF events. While using log entries to gauge contest participation levels may be necessary when using historical data going back in time, relying on non-busted/non-unique callsigns as the basic indicator of contest participation may be more appropriate going forward in time. In this regard, the most recent post-2000 version of the CQ VHF contest stands up very well in a comparison with the ARRL VHF events.

Conclusion

The CQ VHF contests in both eras have

been innovative in style. Most of the major rules changes in the contest do not appear to have affected contest activity very much. The most recent rules change—that of moving to a two-band format in 2000—may have produced a dramatic increase in contest participation, however. The peaks of contesting participation noted in the ARRL VHF contests are not evident in the data that is available on the CQ VHF contest. This may be the result of interruptions in the sponsorship of the *CQ* event at the precise times when new amateurs were hitting the VHF airwaves. Recent CQ VHF contests may be enjoying heightened contest participation levels, especially when viewing information on callsigns and stations worked, instead of the more typical log-entry information.

In comparing the differences between the *CQ* and ARRL contest administrations, each administration generates its own set of strengths and weaknesses. The CQ VHF contest currently can be considered the "seventh" contest having substantial national support and participation from the VHF community. It may also be the only VHF contest of all US, EU, and Asia events to have a truly global following. The *CQ* administration is providing the innovation and flexibility necessary to sponsor a two-band specialty type of contest that the ARRL has so far been unable to develop. To this extent, the two contest administrations may even be complementary in nature. The *CQ* has been the informal testing ground for new and interesting ideas. The ARRL provides the depth of organization and membership support to ultimately incorporate many of *CQ*'s more successful experiments into its own contest structure.

I hope to hear you in the VHF contests.

Acknowledgements

The author thanks the following individuals who provided valuable comments in the preparation of this article: Tom Frenaye, K1KI; Steve Katz, WB2WIK/6; John Lindholm, W1XX; Curt Roseman, K9AKS; Tim Sullivan, KØPG; Bob Witte, KØNR; and Gene Zimmerman, W3ZZ. Bob Brown, W9HBF, even looked at one of the drafts of the article. The reviewers do not necessarily agree with all thoughts contained in this article, but provided the author with many wonderful insights. Thanks also to Karl Bretz, K9BGL, who provided access to his great collection of *CQ*s and *QST*s. ■

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An explanation of the factors involved in VHF contest activity can be found in "A Descriptive Model of VHF Contest Activity," Kevin Kaufhold, W9GKA, *National Contest Journal,* May/June 2005, pp. 14–16.

Historical data on the VHF contests, including the CQ VHF contest, can be found at: <http://www.w9smc.com/SMC%20VHF/uvhfdata.pdf>.

The statistical model is detailed in "A Statistical Model of VHF Contest Activity," to be published in the 2006 conference *Proceedings* of the Central States VHF Society.

A discussion of the non-regulatory factors affecting VHF contest activity is in "Other Impacts on VHF Contests," Kevin Kaufhold, W9GKA, 9-2005 version, and can be found at: <http://www.w9smc.com/SMC%20VHF/OtherImpactsarticle.pdf>. This document also contains a statistical model that tests the various factors and data collected on the VHF contests.

Selling SSB to FMers

With the increased availability of multi-mode rigs on the VHF-plus ham bands comes the potential for introducing other modes, in particular SSB, to the casual FM operator. Here WB6NOA tells how to go about bringing these operators onto the SSB mode.

By Gordon West,* WB6NOA

The new entry-level Technician Class Element 2 question pool goes into effect on July 1st this year. Out go the old 511 questions, and in comes a fresh set of 396 questions specifically geared to more current ham radio technologies:

- VHF/UHF courteous operating technique
- Weak-signal SSB AND CW operation
- Satellite and space communications
- IRLP, Echolink, and data communications
- Interference mitigation
- Licensing and rules and regulations

"There are still 35 multiple-choice questions on the entry-level exam, but the smaller question pool will allow for more classroom demonstrations, such as switching off from FM repeaters and working direct via SSB," comments Bill Alber, WA6CAX, while setting up his VHF/UHF antenna system for an evening class demonstration of OSCAR operation.

Brand-new hams are encouraged to consider VHF/UHF equipment with multimode capabilities. Kenwood, Yaesu, and ICOM all offer new VHF/UHF multimode rigs, but these are relatively expensive (in the $800 and up range). Students are encouraged to look for single-band 2-meter or 440-MHz used radios specifically with multimode capabilities.

"At a recent swap meet I counted ten used, working 2-meter multimode radios for sale, and most were selling for under $200," adds Alber.

Hundreds of hams have VHF/UHF multimode equipment, but only operate on FM. A good hunting ground for weak-signal operators is their local FM net. Have the net controller find out who has SSB capability on 2 meters and encourage them to hang around until the end of the net and meet on upper sideband, at 144.230 MHz.

Yet another hot selling technique for increasing our weak-signal ranks is to frequently announce SSB operation and a specific evening net on your local FM repeater. Before your weak-signal net starts up, switch over to the popular repeater pairs and make an announcement that anyone with 2-meter SSB capability should tune in to "USB," go to the specific frequency for the net, and give SSB a try!

One of the major problems for the FM operator going to SSB is cross-polarization. This is most evident in net operations. Typically, the FM operator uses vertical polarization. However, the SSB operator uses horizontal polarization. Even so, for net operations this need not be a problem if the net control opera-

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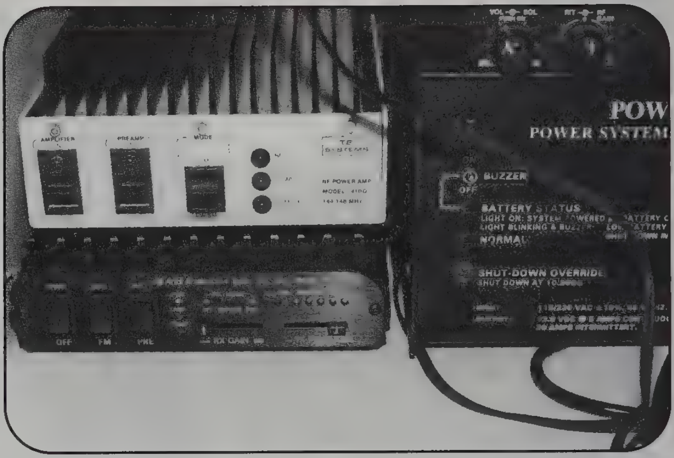


Two-meter amplifiers with built-in preamps will help older "deaf" 2-meter multimode rigs.

The ICOM "fun-mobile" with a pair of 2-meter loops from KB6KQ.

The KU4AB 2-meter SQ-144 in a mobile configuration.

The PAR Electronics horizontal loop is shown here in the middle of the mast.

tor has an antenna switch to connect a vertically polarized collinear antenna at his or her station, or simply work cross-polarized by pointing the beam in the general direction of any vertically polarized stations.

"We actually play up the fact that we are taking check-ins only from stations with vertically polarized antennas, and they really come out of the woodwork on SSB," comments Gabriel, KG6HMN, who is with the Western States Weak Signal Society southern California group. Both Gabriel and I conduct a warm-up net specifically to attract FM stations to SSB, regardless of polarization (see <www.WSWSS.org>).

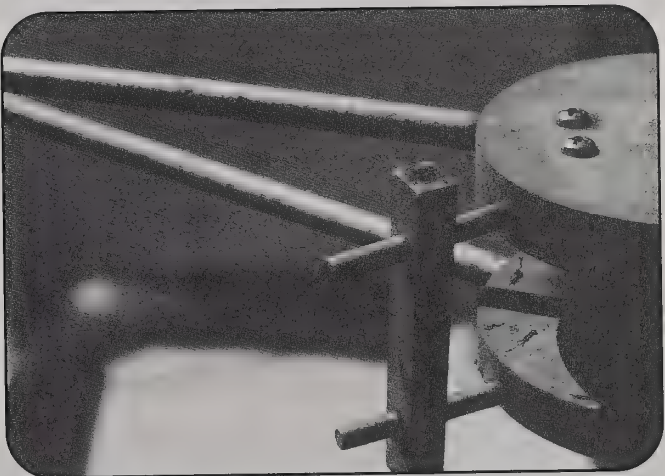
Once we "hook" an FMer into weak-signal work using single sideband, we next need to do another "sales job." They need to add the capability of using a horizontal antenna. No big beam yet—no big tower and a quagi, but rather a modest horizontal loop attached to a roof vent-pipe mast, or maybe hidden in the attic if they live in an area with antenna restrictions.

"There are at least 15 commercially available 2-meter horizontally polarized loop antennas available, all under $100, including some coax cable," comments Julian Frost, N3JF. Here are some of Julian's favorites:

M^2 antennas: on the web <http://www.m2inc.com>
KB6KQ loop: e-mail <kb6kqnorm@aol.com>
Olde Antenna Lab loop: phone 303-841-1354
PAR Electronics omniangle loop: on the web <http://www.parelectronics.com>
Tillo-Currie Big Wheel antenna: phone 734-668-8696
KU4AB loop: on the web <http://www.ku4ab.com>; phone 901-270-8049

How well do these commercially manufactured horizontal loop antennas work? Three years ago, Chip Margelli, K7JA, and I conducted multiple seaside loop tests. We concluded that commercial manufacturers of loops did their homework to achieve a 50-ohm match, minimum nulls, and good mechanical stability.

"While we did see a modest increase in signal strength by stacking a pair of loops, the single loop, horizontally polarized, was light years better than trying to operate cross-polarized with a whip to a distant station horizontal on SSB," comments Margelli, noting the biggest range expansion for SSB operation is similar horizontal polarization. Chip also points out the popularity of single loop antennas tied into mountaintop 2-meter and 70-cm propagation beacons throughout the United States. Under good conditions, a single horizontal loop to a 10-watt transmitter gets received hundreds of miles away!



Tillo-Currie's Big Wheel matching "hairpin" shunt.

Many commercially manufactured loops consist of a square, round, or triangular half-wavelength radiating element, matched either at the feedpoint as a closed loop, or matched opposite the feedpoint with open-air critical capacitive tuning, between 2 and 5 picoFarads.

"It's important to examine the feedpoint matching network to make sure there are no open elements that could be contaminated with dirt or snow," adds Frost, N3JF. "Consideration must also be given to any outside mounting in the wind where rod loop rigidity is important," pointing out the solid rod construction of Phil Brazzell's horizontal omnidirectional antennas, including the most unique dual-band horizontal loops with a single feed line (www.ku4ab.com).

When suggesting that newcomers go to SSB using a horizontal loop, it is important to tell them to first get the loop, and then purchase very large feed line—e.g., Belden 9913, or LMR 400 as a minimum.

"New hams may not realize the losses associated with RG-58 and RG-8X coax cables at frequencies above 50 MHz. Their SSB signals are just terrible, because they're running over 100 feet of the small stuff," comments Ken Neubeck, WB2AMU, author of several books on VHF and UHF operation.

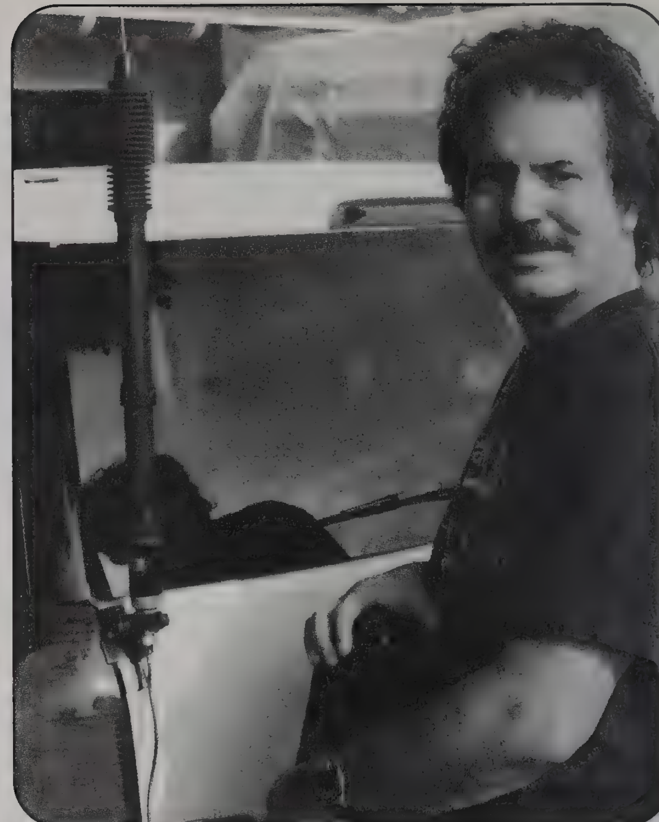
"It's not that they couldn't have run larger coax, it's just that the newer operator who has always been on FM with small coax doesn't realize the requirement for big coax," adds Neubeck, suggesting LMR-400 for runs as short as 25 feet away. Since the loop is essentially 0 dB in all directions, coax loss must be kept to an absolute minimum.

Also, older 2-meter SSB transceivers may lack a hot front end, so an added bonus would be an RF switching preamplifier, such as the SP-144 VDA from Advanced Receiver Research. This hot 15-dB receiver preamp goes down at the rig, not outside. Other ARR mast-mount preamps are available, but for the new ham, running the preamp down below with top-quality coax will certainly get them started big time on 2-meter SSB.

A slight amount of gain is achieved by stacking the loops, and a slight increase in gain is also achieved by going to a physically larger, one-wavelength loop, sometimes called "Big Wheel." Many times the "Big Wheel" is matched with a "hairpin match," and this matching system brings the feed point close to 50 ohms and provides a shunt to bleed off wind static when the loop is mounted outdoors.

Norm Pederson, KB6KQ, points out that since Hurricane Katrina he has had several EOC managers contact him and buy a stack of his loops in order to extend the coverage range of their stations when weather takes out local repeaters. He adds, "VHF SSB range is much better than repeaters, and the EOC guys are beginning to find that there are enough VHF SSB people around such that it pays to have SSB capability in an emergency."

Horizontal loop antennas are an ideal way to bring more FM operators over to the excitement of weak-signal SSB and CW. Many new hams are purchasing equipment that has General class HF features with plans to ultimately upgrade. These rigs normally incorporate 2 meters and 440 MHz multimode. What better time than now to get these hams involved in weak-signal work using SSB, tied into an inexpensive, elevated, well-fed loop antenna as high up in the air as possible. ■



Chip Margelli, K7JA, prepares for loop antenna tests at the beach.

Chip Margelli, K7JA, and WB6NOA conducted multiple loop tests at the beach several years ago. One of the antennas tested was on top of the communications van, shown here.

By Dr. H. Paul Shuch,* N6TX

THE ORBITAL CLASSROOM

Furthering AMSAT's Mission Through Education

Coordinating the Effort

Having recently retired for the second time (the first retirement, in 2004, was from academia; the second, just recently, from industry), I was very pleased to accept appointment to the post of Director of Education for AMSAT-NA. This new column, which will appear from time to time in *CQ VHF,* is derived from material prepared for the *AMSAT Journal,* and appears here by the kind permission of AMSAT. I hope it will serve as a constructive forum for sharing educational resources, and thus furthering AMSAT's educational mission.

Since its inception nearly four decades back, AMSAT has taken on an important role: bringing satellite technology into the classroom. Through our various OSCARs, SAREX, ARISS, and participation in the Cubesat program, many of us have exploited the mystique of space to captivate the interest and imagination of our students. However, we have not always done so in a coordinated manner. Coordination is a skill I most hope to bring to my new assignment.

My first priority as AMSAT Director of Education will be to promote integrated curriculum development at all levels (kindergarten through PhD), with emphasis on using satellites in the classroom to enhance the teaching of science, math, geography, social studies, technology, and the social sciences. To accomplish this, I have turned to the AMSAT membership to lend what significant resources and expertise already exist within our organization. I invite all teachers within AMSAT to share with me their current, past, or planned use of satellites in the classroom, their instructional materials, and their desires in terms of future curricular development. All current or former professional teachers, curriculum developers, and school administrators within AMSAT's ranks are invited to sign up as official AMSAT Educators (sign-up instructions will appear in the Orbital Classroom section of the AMSAT website). You will receive not only a nice certificate, but an opportunity to contribute materially to a coordinated and redoubled AMSAT educational effort.

I respectfully suggest that one key aspect of doing anything in the U.S. educational arena is a need for those efforts to be tied to the federal No Child Left Behind act, as well as the published educational competencies and graduation standards established by the various states. I hope to work together with our cadre of AMSAT Educators to evaluate the competencies and standards in force in the individual states so that our curriculum efforts can tie in to them to the greatest possible extent. Of course, we being AMSAT NA, I rely upon the expertise of our Canadian and Mexican AMSAT Educators to bring me up to date on the educational standards and curriculum requirements throughout the rest of North America.

One area in which AMSAT already has a rich history of educational activities is human spaceflight, most recently through the ARISS Program. I would not presume to modify these existing programs in any way. However, ARISS contacts should not be an end unto themselves. ARISS generates a great deal of enthusiasm, leading up to a contact with the astronauts on the International Space Station. Coordinating closely with Frank Bauer, KA3HDO, AMSAT VP for Human Spaceflight, I will be seeking ways we can encourage ARISS schools and teachers to take the next step, with programs to leverage that enthusiasm into an ongoing interest in math, science, and amateur radio.

Another key area of attention for me as the new Director of Education will be Cubesats. There is a definite educational mission in satellite construction, which goes far beyond the production and launch

(Continued on page 36)

The first-ever back-to-back ARISS QSOs took place on February 7, 2006. The first was with the Dale, Oklahoma public schools. The second was with the DeGolyer Elementary School, Dallas Texas. Students from the Dale school, plus others, are shown here gathered to listen to Expedition 12 Commander Bill McArthur, KC5ACR, respond to the DeGoyler school students' question. ARISS QSO mentor Keith Pugh, W5IU, is at the controls of the Dale ham radio station. (N6CL photo)

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By Kent Britain,* WA5VJB

Connecting the Radio to the Sky

GPS Antenna Project

There have been a couple of requests for a GPS (global positioning system) antenna construction project, but I am not sure how much it will help many of you. The problem is that those expensive little external antennas for your GPS receiver contain a high-gain, low-noise preamp. This preamp has been designed to work with the control voltage your GPS receiver sends back up the coax. I am unaware of any universal design for GPS antennas with integral preamps.

Shown in photo A is the ceramic element from an external GPS patch antenna. The dielectric constant of the ceramic material greatly reduces the size of the antenna. The trimmed corners create an imbalance in the patch, which gives you circular polarization. If you don't trim off enough from the corners, the polarization will be more vertical than horizontal. If you trim off too much, the polarization will be more horizontal.

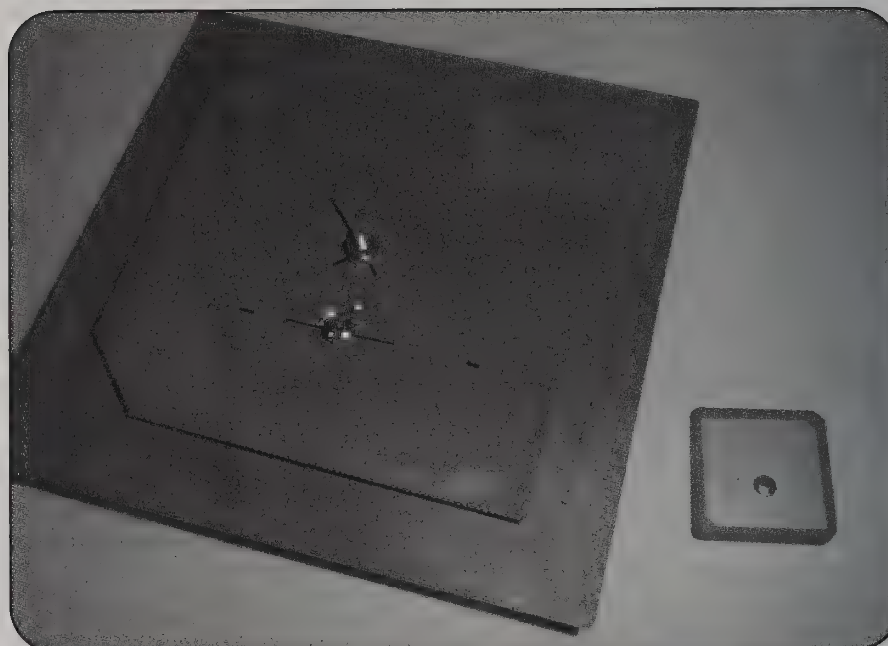

Photo A. Ceramic and homebrew GPS receivers.

For our prototype, the dimensions for the patch were tweaked on a network analyzer and the corners were trimmed for circular polarization on the antenna range (figure 1). Since I am using air dielectric, the antenna is much larger than the ceramic version.

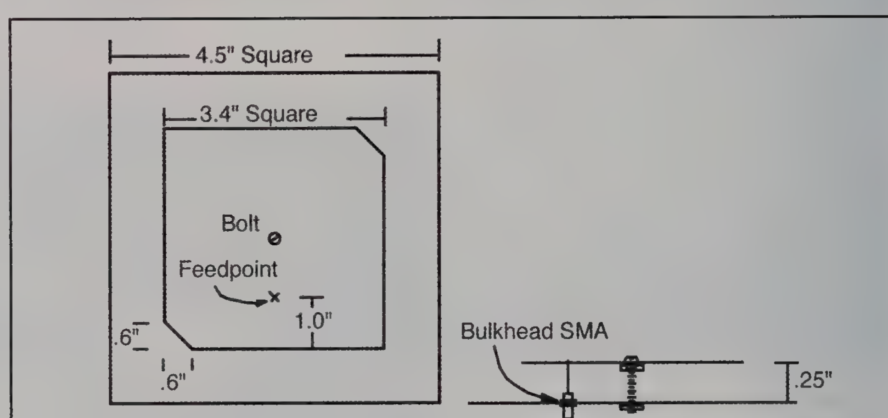

Figure 1. Dimensions for the patch antenna.

Normally, we would have a much bigger ground plane under the patch. However, for GPS most of the birds are near the horizon, so we don't want the higher gain of a large ground plane. Again, the corners were trimmed to make the patch circularly polarized.

Construction

I used double-sided .031-inch PC board, but sheet brass or sheet tin would work just as well. You can use aluminum, or most any sheet metal for the base, but it's a lot easier if the patch is made out of something you can solder, too.

The very center of the patch is a null point. I used a 4-40 screw as the patch support, but if for some reason you need the patch to be electrically isolated, a plastic screw could be used, or the patch just could be supported on a small block of plastic. Again, the very center is a voltage null point, like the center of a Yagi antenna element.

The corners are cut for receiving GPS signals. If you are building a GPS simulator and want to transmit to a GPS receiver, you need to reverse the circular polarization. In this case, just trim back the opposite corners off the patch .6 inch.

Feedpoint

For this antenna the impedance at the edge of the patch was a bit over 150 ohms. By definition, the center of the patch is zero ohms. The impedance curve is not

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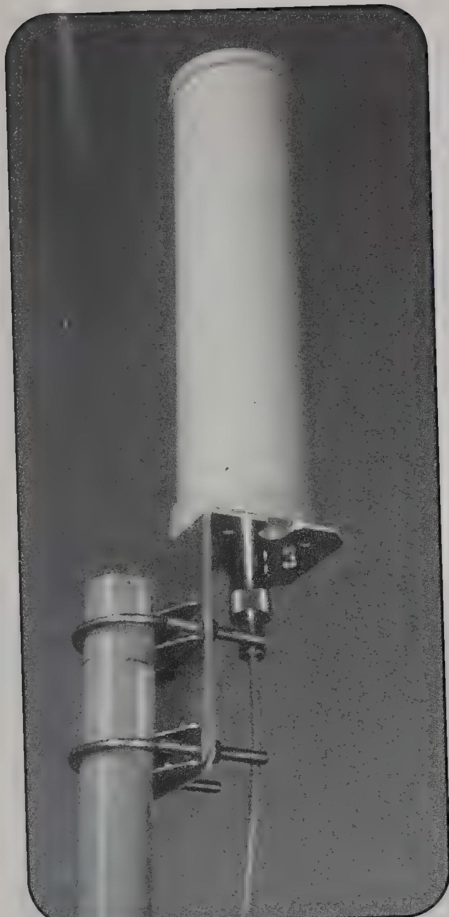

Photo B. A 5.8-GHz omni antenna, also known as a collinear-coaxial array.

exactly a straight line, but with a little experimentation, the 50-ohm point was right at 1 inch from the edge.

This should be an interesting project for those of you with specialized GPS antenna needs.

Neat Antennas

I was asked to make some measurements with a 5.8-GHz omni antenna (photos B and C). Known as a *collinear-coaxial array,* it starts out as a 1/4-wave section and ends with a 1/4-wave section, with alternating 1/2-wave sections in the middle. The RF energy goes through the inside of the coax, and then on the outside of the coax. When the RF energy is on the outside of the coax, it behaves like a 1/2-wave dipole. Stack up a bunch of them, and you have a collinear array made of out sections of coax. The one shown is a commercial version; it is neatly engineered, in that two pieces of brass and one piece of Teflon® are used to make virtually the entire antenna.

Some similar antenna construction projects with claims that defy physics are floating around on the internet. The first problem is power distribution. In theory, making a vertical collinear array twice as long gives you 3 dB more gain. However, if you are using a coax power divider, then you have at least twice as much coax. Loss in the coax means you are going to be lucky to get 2 dB gain. (Commercial guys who are using 6-inch EIA flanges are in a different league!)

With this kind of vertical collinear the first section gets all the power, the second section gets less power because some has already been radiated, and so on and so on. Thus, the top section does not get its share of RF power and gain is not as high as might be realized. Make the antenna with twice as many sections, and this problem becomes even worse. There is not much RF left at the end of two dozen sections. Therefore, doubling the number of sections does not give you 3 dB more gain, even with low-loss coax.

With really long versions you have another problem they like to leave out. . . .

Beam Tilt

On the design frequency the waves are in phase at each element and the maximum signal is 90 degrees to the antenna (figure 2). Change frequency, though, and the angle changes. Go up in frequency and the beam tilts downward. Go down in frequency and the beam tilts upward. While the antenna may have a good SWR at 5.8 GHz and 5.2 GHz, only one of these frequencies will be towards the horizon with a really long vertical collinear. Very, very few of the vertical collinears I have tested had the design frequency 90 degrees to the antenna. You have to measure distances very carefully and know the velocity factor of your coax when the antenna is made up of more than a few sections. Even then, it takes a couple of tries to get it right.

Letters

A comment to Terry: Sorry, but I have no plans to publish any J-pole antenna designs, as I feel that area has been thoroughly covered.

From Indiana there was a question of using other driven elements with Cheap Yagis. The short answer is "not with the published dimensions." The driven element impedance of the J element is near 150 ohms. By using the loading effect of the reflector and directors, the impedance is pulled down to 50 or 72 ohms. This

makes it practical to just solder coax directly to the driven element. If the driven element is 72 ohms for a regular dipole—or, say, 300 ohms for a folded dipole—you will not get a good impedance match to the coax using Cheap Yagi dimensions. That is, the antenna will have a high SWR. The idea of employing the same technique of using the structure of the Yagi itself for impedance matching can be applied to other driven elements. You just have to re-calculate all the lengths and spacings of the other elements.

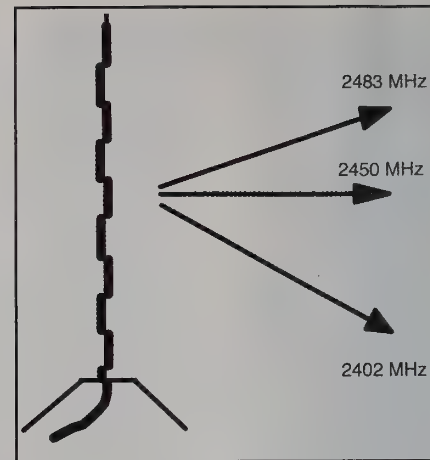

Figure 2. Side view of the antenna.

Cheap Yagis Website

My original 1994 paper on building Cheap Yagis has been updated a bit and is available as a download from my website, <www.wa5vjb.com>. Look in the reference section. Some other good papers are there as well, and I'm adding more all the time.

Please keep those e-mails coming! I'm always looking for project ideas.

73, Kent, WA5VJB

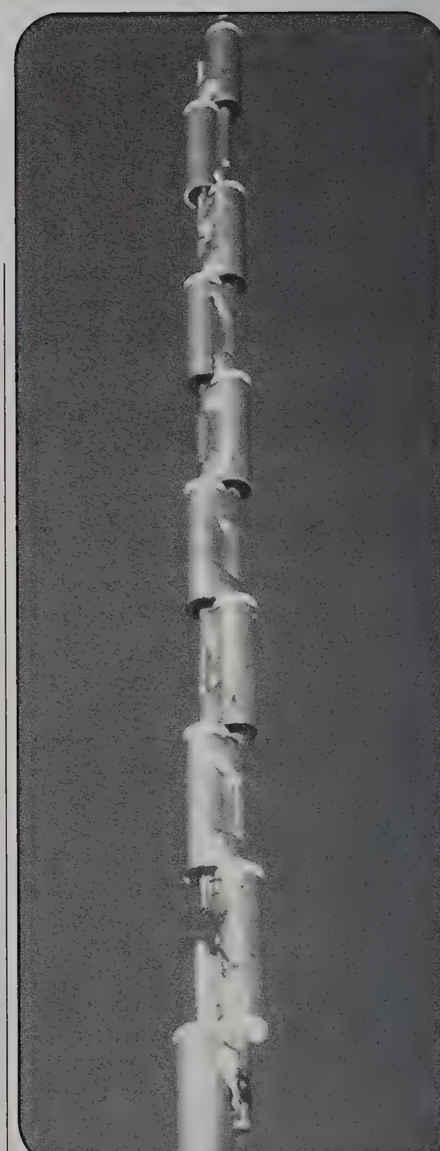

Photo C. Close up of the 1/2-wave elements.

THE ORBITAL CLASSROOM

(from page 31)

of a payload. We should be seeking to find a way to get satellite builders talking to satellite users, in an educational setting. It is my hope that, by finding specific educational applications of existing and planned small satellites, and by providing proper training to satellite developers, we will get them fired up about supporting the classroom use of their creations.

AMSAT has a proud history of both technical and educational accomplishment. With the help of satellite enthusiasts everywhere, we can make great strides. I thank AMSAT president Rick Hambly, W2GPS, and his senior leadership team, for providing me with this opportunity to further serve an organization that has been near and dear to my heart for three and a half decades (which, incidentally, is about as long as I taught). I thank *CQ VHF* editor Joe Lynch, N6CL, for providing me with this bully pulpit from which to preach satellites in education. And finally, I thank *AMSAT Journal* editor Ed Long, WA4SWJ, for his kind permission for *CQ VHF* to reproduce some of my *AMSAT Journal* material. With their help, I'll certainly not be bored in my second retirement!

73, Paul, N6TX

D-STAR Test Results with FEMA and the US Army

Last year's devastating hurricanes revealed huge problems with communications integration. Here N9JA reveals how ICOM's D-STAR could be used as a possible solution.

By Ray Novak,* N9JA

I want to share with you information from our demonstration for FEMA and the US Army. I think it is about time to let the cat out of the bag.

Early in 2006, ICOM and several other vendors were asked to participate in a demonstration for FEMA and the US Army. The demonstration was designed to illustrate possible solutions to some of the communications issues experienced during the responses to Hurricanes Katrina and Rita last year.

In mid-February, the vendors and some volunteers gathered discretely to show the capabilities of an integrated communications design that included high-speed network connectivity via satellite, multiple mechanisms to transport network data, WiFi, and interconnected voice capabilities via VoIP, standard FM, and digital voice with D-STAR. The premise of the exercise was to illustrate a group of first responders actually being deployed, then having that team relay vital tactical and strategic information to other team members hundreds to thousands of miles away, and provide a seamless integration of this information into existing networks. The operation required full integration of voice and data networks, along with adding significant data capability to individuals in the response team.

While there were many items covered in our demonstration, I will focus just on the amateur radio portion of this demonstration.

Demonstration Overview: Both tactical and strategic communications relayed to the proper authorities through an integrated voice and data network.

Long-Haul Communications: For the long-haul communications, both FEMA and the US Army requested that our focus shift from HF to new and more robust communication methods. One comment that was made during the demonstration was "Why say it, when you can send it?" This underscored the importance of concise, accurate communications capabilities.

Thus, the primary focus was data, data, and more data. The government agencies obviously have satellite data solutions. The most recent solution to come on line is Hugh's R-BGAN Satellite solution. For those who are interested, there is a great resource of information on the R-BGAN technology at: <http://www. aosusa.com/bgan.html>.

With the bandwidth that was available with the R-BGAN technology, there was a lot of normal, everyday type communications being provided via network as well as VoIP communications. I realize that none of this really pertains to amateur radio, but this needs to be shared here so you see how D-STAR integrated seamlessly into the local communications network.

Now to the core of the D-STAR demonstration! There were some specific requests from FEMA and the US Army that needed to be addressed for the first responders. Here are some of them, and how we were able to immediately meet the requirements with D-STAR's simultaneous voice and data capabilities:

- First responder communications identification: D-STAR's Automatic Callsign TX with voice communications.
- First responder location (when landmarks are either below water level or no longer standing): D-STAR GPS/callsign along with voice communications.
- First responder assessment data: Transmission of data files using same-site repeater structure as voice communications.
- Last mile (really 30 mile) data coverage: Combination of 1-kbps and 128-kbps data.

1 kbps = small data files from "in-field" responders
128 kbps = mobile officials retain data connectivity for e-mail or WLAN network
128 kbps = level 2 communications networks outside WiFi range (connected to SATCOM data)

While some laughed at the 1-kbps data, it was really effective in moving FEMA incident-type reports. What we did was store the data locally, and then push a CSV file over the 1-kbps data stream. Once the file was received, the server expanded and populated a website with the details.

From the comments heard at the exercise, it was apparent that our traditional thoughts of providing "out of area" communications with HF should shift to providing "in-area" augmentation of data and voice capabilities. These functions won't replace our existing agreements and relationships with served agencies, but if we can add these new capabilities to our offerings, our services become much more attractive to some of the federal agencies.

We all agreed that the exercise was a huge success. While we can't share any of the specific details about the exercise and we don't know anything about future government directions, we do know that there is significant interest in expanding data communications capabilities for emergency communications. We were proud to be able to quickly respond and satisfy the requirements of the exercise organizers. We successfully demonstrated the capabilities of both the D-STAR technology and the spirit of the amateur radio community.

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By Tomas Hood,* NW7US/AAA0WA

PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

The Cycle Minimum is Here
Cycle 24 Predicted to be the Best in 50 Years!

The start of the solar Cycle 23 minimum has officially been declared, signaling the fast approach of the end of the roughly 11-year sunspot cycle. Most likely, the end of the current cycle will be in December 2006, with the start of Cycle 24 occurring in January 2007.

The official declaration of the arrival of solar minimum was made by NASA, whose solar scientists believe that we're now witnessing the ending of the current sunspot cycle. This assessment is based on the frequent longer periods of solar calm, when for many days at a time the sun has no visible sunspots. The first of these significantly long periods of total solar quiet was the 10-day run starting on January 29, 2006, when there were no sunspots on the visible sun. Nearly the entire month of February passed without sunspots, too. There were sunspots on only nine days in February. During solar minimum whole months can go by without a single sunspot.

February 2006 was the first month in almost ten years with mostly no sunspots. We can now expect this situation to continue for the rest of 2006, until the next cycle, solar Cycle 24, fires up.

Without any significant sunspot activity, there's very few, if any, solar flaring or coronal mass ejections. When sunspots develop, they tend to be small and not very complex, triggering only minor flares which rarely exceed the C-class X-ray classification. This low solar activity means that VHF radio propagation via the *F*-layer is non-existent, because the ionosphere can only refract radio signals when it is energized by solar energy.

In May, and during the rest of the year, we still may have occasional sunspots and solar flares. During the first week in April 2006, for instance, we saw *K*-index readings of 6, indicating significant geomagnetic activity. This storm-level geomagnetic activity triggered a bit of aurora, which could have been enough to support aurora-mode propagation and sporadic-*E* propagation via the auroral ionization. During this same period in April, the 10.7-cm flux readings reached 100.

Historically, during each of the last three solar cycle minima in 1976, 1986, and 1996, the sun unleashed at least one X-class flare and produced at least one giant sunspot. However, the overall condition is a very quiet sun. Perhaps we're in store for a surprise event that could wake up VHF activity during this period (May, June, and July).

Solar Cycle 24—The Best in 50 Years

In March 2006, a team led by Mausumi Dikpati of the National Center for Atmospheric Research (NCAR) announced that the new solar Cycle, the 24th since sunspots were faithfully recorded, will be the most intense solar maximum in 50 years. Researcher Dikpati says, "The next sunspot cycle will be 30 percent to 50 percent stronger than the previous one." If this prediction is correct, the solar activity in just a few years will be second only to the historic solar cycle maximum of 1958.

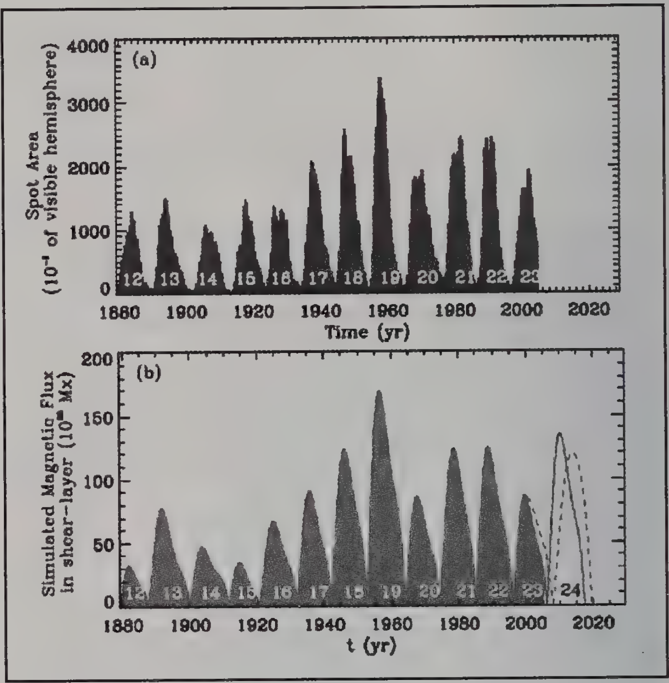

Figure 1. (a) Observed spot area (smoothed by Gaussian running average over 13 rotations) plotted as function of time. (b) Simulated toroidal magnetic flux in the overshoot tachocline within mid-latitudes for the case with a steady meridional flow (solid red area and curve) and with the time-varying flow incorporated since 1996 (dashed red curve). (Source: "Predicting the strength of solar cycle 24 using a flux-transport dynamo-based tool," by Mausumi Dikpati, Giuliana de Toma, and Peter A. Gilman, in Geophysical Research Letters, Vol. 33, L05102, doi: 10.1029/2005GL025221, 2006)

Veteran amateur radio operators remember that cycle. The solar activity was so strong that aurora was sighted three times in Mexico. Propagation on 6 meters and higher was open worldwide and for great lengths of time.

The NCAR team's prediction is unprecedented, and goes against the prevailing predictions, such as the popular forecast based on a precursor method. The precursor method predicts

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solar Cycle 24 will be considerably smaller than Cycle 23. In nearly two centuries since the 11-year sunspot cycle was discovered, scientists have struggled to predict the size of future maxima. Every time, they mostly failed. The new prediction is based on a flux transport dynamo model, which has the ability to correctly "forecast" the relative peaks of cycles 16 through 23, using sunspot area data from previous cycles.

Various methods of predicting the properties of an upcoming solar cycle that use old cycle data have been attempted since 1978. A particularly popular current method involves the use of polar fields from previous cycles as ''precursors'' of the next cycle.

The new method has been demonstrated to reproduce many solar cycle features, and is now considered the most reliable and accurate way of predicting the intensity and nature of the next sunspot cycle. The dynamo-based scheme of a group of researchers (K. H. Schatten, P. H. Scherrer, L. Svalgaard, and J. M. Wilcox, in their research paper entitled, "Using dynamo theory to predict the sunspot number during solar cycle 21," published in *Geophysical Research Letters,* Volume 5, pages 411–414) attempted to make a physical connection between the strength of an upcoming sunspot cycle and the previous cycle's polar fields, assuming that there is a ''magnetic persistence'' between these two. This ''magnetic persistence'' was based upon a relation between the surface polar fields and the spot-producing toroidal fields, generated by differential rotation shearing (the W-effect). Implicit in this ''dynamo based'' approach is that the polar fields of the previous cycle can be sheared by the solar differential rotation in time to produce toroidal fields of the new cycle.

Digging into the 1978 model, the NCAR team asked questions that finally led them to reveal that the sun has a memory about its past magnetic fields, a memory that spans at least 17 to 21 years.

The key to the mystery is a conveyor belt on the sun consisting of electrically conducting gas. We have something similar here on Earth, known as the Great Ocean Conveyor Belt. It is a network of currents that carry water and heat from ocean to ocean.

The sun's conveyor belt is a current that flows in a loop from the sun's equator to the poles and back again. Just as the Great Ocean Conveyor Belt controls weather on Earth, this solar conveyor belt controls weather on the sun. Specifically, it controls the sunspot cycle.

Solar physicist David Hathaway of the National Space Science & Technology Center (NSSTC) explains: "First, remember what sunspots are—tangled knots of magnetism generated by the sun's inner dynamo. A typical sunspot exists for just a few weeks. Then it decays, leaving behind a 'corpse' of weak magnetic fields."

Hathaway explained how "the top of sun's conveyor belt skims the surface of the sun, sweeping up the magnetic fields of old, dead sunspots. The 'corpses' are dragged down at the poles to a depth of 200,000 kilometers, where the sun's magnetic dynamo can amplify them. Once the corpses (magnetic knots) are reincarnated (amplified), they become buoyant and float back to the surface." And that's how we get new sunspots.

All this happens with massive slowness. "It takes about 40 years for the belt to complete one loop," says Hathaway. The speed varies "anywhere from a 50-year pace (slow) to a 30-year pace (fast)."

When the belt is turning "fast," it means that lots of magnetic fields are being swept up, and that a future sunspot cycle is going to be intense. This is a basis for forecasting: "The belt was turning fast in 1986–1996," says Hathaway. "Old magnetic fields swept up then should re-appear as big sunspots in 2010–2011."

Like most experts in the field, Hathaway has confidence in the conveyor-belt model and agrees with Dikpati that the next solar maximum should be quite active (see figure 1). However, he disagrees with one point: Dikpati's forecast puts the next solar maximum at 2012. Hathaway believes it will arrive sooner, in 2010 or 2011.

Either way, it is clear from current observations that solar Cycle 23 is at its end, and for the rest of 2006, we're in for mostly quiet solar activity. With that, we see very little higher frequency propagation except that occurring via sporadic-*E*, tropospheric ducting, and other non-*F*-layer propagation.

Aurora and Sporadic-Aurora-*E*

We are still seeing moments when coronal holes trigger geomagnetic disturbances, such as the one during the beginning of April 2006. The frequent occurrence of coronal holes may bring brief moments of life to 6 meters. Watch the spots on the OH2AQ DX Summit <http://oh2aq.kolumbus.com/dxs/> if the *K*-index rises above 5. If such a period of geomagnetic activity occurs, aurora-mode propagation (*Au*) as well as sporadic-Aurora-*E* (*Au-Es*) (like sporadic-*E,* except caused by highly ionized patches at the *E*-layer height caused by auroral activity) may provide the opportunity for North American VHF operators to engage in quick QSOs.

Sporadic-*E*

Sporadic-*E* propagation is an exciting but mostly unpredictable mode related to "clouds" of highly ionized, dense, small patches in the *E* region of the ionosphere. Ten-meter operators have known *Es* propagation as the summertime "short skip." These "clouds" appear unpredictably, but they are most common over North America during the daylight hours of late spring and summer. *Es* events may last for just a few minutes up to several hours, and usually provide an opening to a very small area of the country at any one time.

During periods of intense and widespread sporadic-*E* ionization, two-hop openings considerably beyond 1400 miles should be possible on 6 meters. Short-skip openings between about 1200 and 1400 miles may also be possible on 2 meters.

How can we know when a sporadic-*E* opening is occurring? Several e-mail reflectors have been created to provide an alerting service using e-mail. One is found at <http://www.gooddx.net/> and another at <http://www.vhfdx.net/sendspots/>. These sporadic-*E* alerting services rely on live reports of current activity on VHF. When you begin hearing an opening, you send out details so that everyone on the distribution list will be alerted that something is happening. They, in turn, join in on the opening, making for a high level of participation. Of course, the greater the number of operators on the air, the more we learn the extent and intensity of the opening. The bottom line is that you cannot work sporadic-*E* if you are not on the air when it occurs.

In addition to live reporting, there is a very powerful resource available on the Internet. Check out <http://superdarn.

jhuapl.edu/>. SuperDARN (Super Dual Auroral Radar Network) is an international radar network for studying the Earth's upper atmosphere and ionosphere. Using the SuperDARN real-time data 24-hour overview, you can view the day's ionization activity at the northern polar region. You can also view live radar displays of the same area. These graphs help identify *Es* clouds existing in the higher latitudes. One use for this would be the detection of a variation of *Es*, known as Auroral-*E*.

For a great introduction to mid-latitude sporadic-*E* propagation, visit the AM-FM DX Resource website <http://www.amfmdx.net/propagation/Es.html>.

Tropospheric Ducting

Scattered reports of some very strong tropospheric openings have been made during April (corresponding to severe spring weather), but we don't typically see widespread tropospheric ducting until summer. In tropospheric ducting, radio waves are trapped in a type of natural wave-guide between an inversion layer and the ground or between two inversion layers. Ducting causes very little signal loss and often signals are only heard at each end of the wave-guide. Ducting via the troposphere can propagate signals great distances, for instance from Hawaii to California. This ducting depends on large weather systems, however, that are more common during the late summer. With the early reports, though, it is worth watching for this mode of propagation. The summer weather season may well be violent and eventful.

Advanced visual and infrared weather maps can be a real aid in detecting the undisturbed low clouds between the West Coast and Hawaii or farther during periods of intense subsidence-inversion band openings. This condition also occurs over the Atlantic. There is a great resource on the Internet that provides a look into current conditions. Bill Hepburn has created forecast maps and presents them at <http://home.cogeco.ca/~dxinfo/tropo.html>, which includes maps for the Pacific, Atlantic, and other regions.

If you know that conditions are favorable for tropospheric ducting in your area, try tuning around the 162-MHz weather channels to see if you can hear stations way beyond your normal line-of-sight reception. It is possible to hear stations over 800 miles away. Amateur radio repeaters are another source of DX that you might hear from the other end of the duct.

These openings can last for several days, and signals will remain stable and strong for long periods during the opening. The duct may, however, move slowly, causing you to hear one signal well for a few hours, to then have it fade out and another station take its place from another area altogether.

Meteor Showers

The *Eta Aquarids* meteor shower will occur in May. The *Eta Aquarids* will peak on the morning of May 6, but start around April 21, 2006. This shower is expected to have a peak rate of up to 60 per hour this year. It is expected that this shower will have a broad period of maximum activity, starting as early as May 3 and extending out to May 10. Also, because of the low radiant, the meteors tend to have long ionized paths, making for strong signal reflections. Look for 6- and 2-meter openings off the ionized meteor trails.

June may have a strong shower, the *Boötids*. This shower is active from June 26 through July 2, with the peak occurring on June 27 at 1400 UT. The hourly visual rate can reach as high as 100 or more. Following its unexpected return in 1998, when the hourly visual rate was between 50 and over 100 for more than half a day, this shower is worth watching for. Another occurrence of significant activity with an hourly visual rate between 20 and 50 was observed in 2004. The shower was from Comet 7P/Pons-Winnecke, which has an orbit that now lies around 0.24 astronomical units outside the Earth's at its closest approach.

July has only minor showers. These showers have not typically yielded much radio activity. For more information on these, take a look at <http://www.imo.net/calendar/2006/>.

Trans-Equatorial Propagation

A seasonal decline in transequatorial (TE) propagation is expected during May. An occasional opening may still be possible on VHF. The best time to check for VHF TE openings is between 9 and 11 PM local daylight time. These TE openings will be north-south paths that cross the geomagnetic equator at an approximate right angle.

The Solar Cycle Pulse

The observed sunspot numbers from December 2005 through March 2006 are 41.2, 15.4, 4.7, and 10.8. The smoothed sunspot counts for June through August 2005 are 28.9, 25.9, and 27.5.

The monthly 10.7-cm (preliminary) numbers from December 2005 through March 2006 are 90.8, 83.8, 76.6, and 75.5. The smoothed 10.7-cm radio flux numbers for June through August 2005 are 91.9, 87.8, and 89.3.

The smoothed planetary *A*-index (*Ap*) numbers from June through August 2005 are 13.9, 11.8, and 12.2. The monthly readings from December 2005 through March 2006 are 7, 6, 6, and 8. These are significantly quieter than last year.

The smoothed monthly sunspot numbers forecast for May through July 2006 are 11.1, 9.1, and 7.2, while the smoothed monthly 10.7-cm is predicted to be 75.0, 73.4, and 71.9 for the same period. Give or take about 12 points for all predictions (yes, that means that the smoothed sunspot figures could be zero for any of these months, since we are now at solar cycle minimum). Note that these are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review.

Feedback, Comments, Observations Solicited!

I am looking forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail, or drop me a letter about your VHF/UHF experiences (sporadic-*E*, meteor scatter . . .). I'll create summaries and share them with the readership. I look forward to hearing from you.

You are welcome to also share your reports at my public forums at <http://hfradio.org/forums/>. Up-to-date propagation information is found at my propagation center, <http://prop.hfradio.org/> and via cell phone at <http://wap.hfradio.org/>.

Until the next issue, happy weak-signal DXing.

73 de Tomas, NW7US

By Del Schier,* K1UHF

AIRBORNE RADIO

Using Amateur Radio to Control Model Aircraft

Radio Systems

This time I will cover RC (radio control) radios, the transmitters and receivers. There is no such thing as an RC transceiver . . . well, not quite. There are transceivers. More on their unique features will be found below. Normally, the transmitter, the part with the controls, is in your hands, while the receiver is in the airplane. The receiver controls the servos, which in turn control the airplane. The servos, in turn, are linked back to your fingertips with proportional control.

Many years ago I remember seeing old-time RC equipment at the ARRL museum. I don't think it is on exhibit any more. However, I couldn't get over how big and heavy everything was. The transmitter was a big wooden box, with a stick and a couple of switches, along with legs to support the transmitter on the ground. The airborne equipment, even with the relative lightness of subminiature tubes, was nevertheless weighted down by filament and plate batteries, requiring a big airplane to carry everything aloft. My first radios, made by Futaba™ and Kraft™, were in aluminum boxes that looked like standard Bud™ mini boxes. Now they look like something from *Star Wars*.

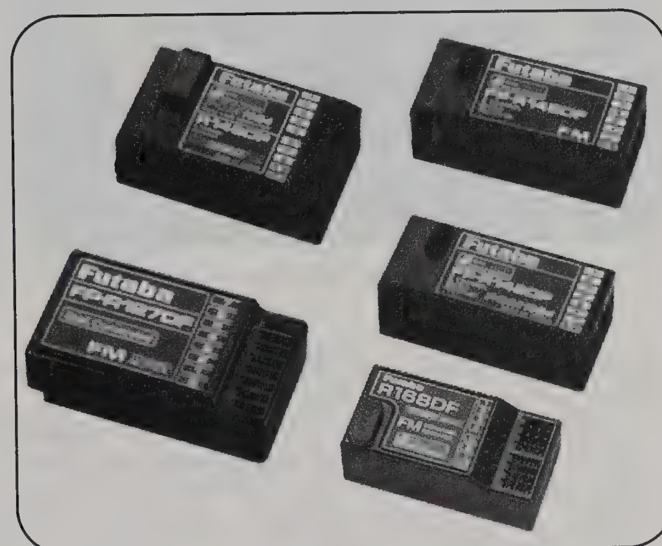
Today's RC radios are as modern as any other type of electronics, with digital technology adding endless features. Choosing your first RC radio equipment can be confusing, so here are the basics.

The Basics

RC transmitters and receivers are primarily classified by the number of channels they have, but there is much more. When I speak of channels, I refer to the number of control channels that the radio controls, rather than the frequency channel. To begin, you probably will need only three channels—one each for throttle, elevator, and rudder. It is hard to find a three-channel system. Even so, you should start out with more so that you can graduate to more sophisticated airplanes. To fly on the 6-meter ham band, you have no choice because the commercially available 6-meter radios all have seven or eight channels.

Manufactures that supply 6-meter transmitters and receivers include Futaba, JR, and Airtronics™. They only offer 6 meters

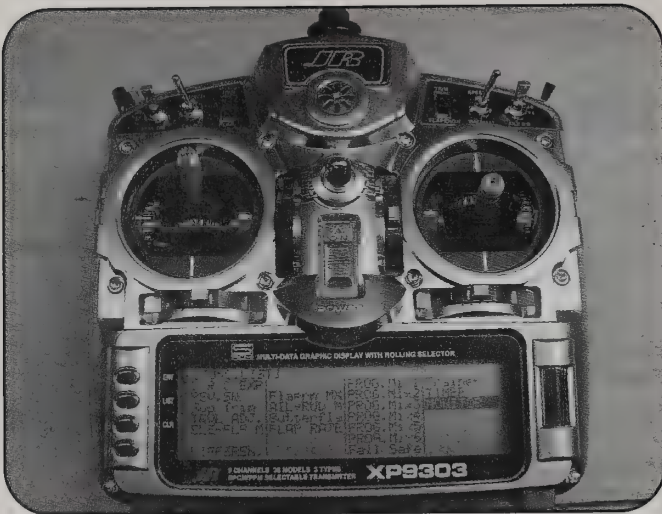
*e-mail: <k1uhf@westmountainradio.com>



Futaba 6-meter receivers come in various sizes and levels of performance.

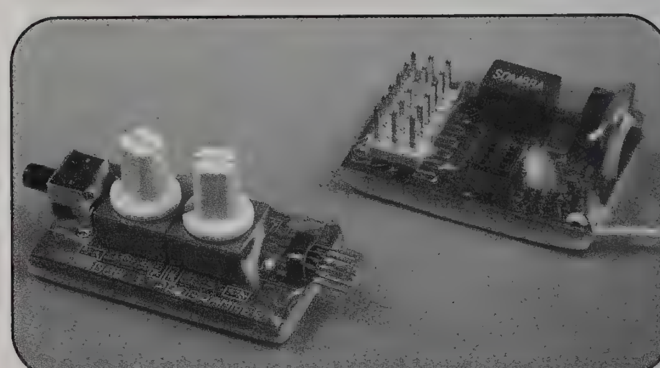
Airtronics 6-meter transmitter modules which plug into the back of the company's transmitters.

The RC equivalent of an IC-7800 or FT-dx9000.



A JR 9303 transmitter, near top of the line, but affordable.

A module-equipped Airtronics transmitter.



The micro Sombra with programming module.

in transmitters that have a plug-in transmitter module, a small RF deck that plugs into the back of the transmitter. These transmitters are their better versions, but they are relatively inexpensive. I purchased a used JR X347 module radio in perfect condition for $75 at the local hobby shop. My best new radio, a JR 8103, was $300. Both radios have about all the features an advanced modeler would need.

Anything but a very entry-level RC transmitter will be a "computer radio." Computer radios allow you to do things with RC airplanes that full-size airplane designers only wish they could do. A modern RC transmitter has functions similar to what a fly-by-wire Airbus or jet fighter might have.

Computer radios allow you to control everything any way you wish. In the U.S. (mode II system), the right stick usually controls elevator and ailerons, just like a real airplane stick. The left stick's up and down directions control the throttle. The left and right directions control the rudder. Note that simple airplanes without ailerons use the right stick, aileron channel, to control the rudder. Simple rudder-and elevator-only airplanes will roll right and left with rudder input due to dihedral in the wing.

Those are the basic controls. What about the other knobs and switches? Slider controls that are located alongside and below the sticks are "trim" adjustments. These trims function the same as trim controls in a full-size airplane—that is, they control how the airplane flies hands off.

The trim levers are especially important on a first flight with a newly built airplane. If the airplane was not built or designed correctly, the trims make it possible to quickly set the airplane to fly hands off. It is very difficult to hold the sticks to one direction to keep the airplane level. Therefore, the trims take care of that problem. Trims can also be set for landing, descent, or other modes of flight.

Most modern radios have something called "trim memory." Once you find the best trim settings for a plane, the radio will remember them. Then on the next flight the trim sliders can be centered. Most trims move a potentiometer, but some radios have digital trims that audibly beep their settings.

Depending on what you want your airplane to do, other switches can be used. The other controls may be customized to do different things, depending on how you program the radio. A switch can set the airplane for landing flaps down, and possibly gear down. Other switches can give you a choice of dual rate control throws (wild and tame, expert and easy, aerobatic and normal, for example). Switches can start or stop timers for fuel or duration. A momentary contact switch can perform an aerobatic snap roll. A typical use for a switch is to select a programmed mix.

A powerful feature of a computer radio is the ability to have programmable mixes. These mixes can remain on, or be selected by a switch. One example is a throttle-to-elevator mix that keeps the airplane from pitching up when power is applied. A mix might be turned on and off to couple the ailerons to the rudder to make the plane fly nice turns while only using one thumb on the right stick. However, this rudder mix should be turned off so as to properly fly aerobatics that require independent control of the rudder. As one can see, there are endless uses for the mixing capability of a modern computer radio.

A more exotic use of mixing is a camber mix, where the ailerons and/or flaps all can be raised or lowered together, allowing the airfoil shape to be changed and optimized for slow or fast flight. This could have the elevator channel mixed

A PCM (pulse-code modulation) FM transmitter module from Japan Remote Control Co., Ltd.

The Futaba FP-TP-FM RF transmitter module.

to the two flaps and the ailerons so whenever the plane is slowed with up elevator, the wing's trailing edge is lowered slightly, thereby generating more lift. The opposite is possible, too, thus creating less drag.

By the way, lift and drag are what wings are all about. This mix can be used in a sailplane to make it climb faster in a thermal updraft, or to glide farther when flying fast, or to cause a 3D aerobatic airplane to perform outrageously small loops and flips.

Before computerized radios, installing servos and control linkages had to be done precisely so the controls could move correctly. Now it is much easier; the servos only need to be set to center of travel. The radio is then programmed to set the correct direction and amount of trav-

A micro-size DSP receiver available soon on 50 MHz.

el. Computer radios can be set to have exponential rates that soften or increase the control resolution near the center of stick travel. To my knowledge, all RC radios have a basic digital resolution of 10 bits (1024 steps) for control.

Receivers have 4.8-volt batteries and transmitters have 9.6-volt battery packs. These batteries usually are nickel rechargeable, and can be expected to operate more than one hour on a single charge. Generally, if these batteries are charged the night before flying, you will not have to worry about losing an airplane. Transmitters have low battery warning beepers and/or metering, just in case.

Now, about those transceivers: The reliable RF range for most radios is as far as you can see the airplane and still fly it. However, there are some circumstances when interference from an improper airborne electric motor, antenna installation, or external source will greatly reduce the range. If someone at your flying field turns on a transmitter on the same frequency as someone else who is already flying, that flyer can count on an airplane being lost. To deal with this problem, there are some transmitters that are transceivers that actually have a receiver listen and check for a clear frequency before transmitting. Normally, frequency control is done with a board with frequency pins, and that control is taken seriously. On 6 meters there is less chance of conflict, because there are fewer users due to the ham radio license requirement for operating on this band.

Radios usually come packaged with transmitter, receiver, servos, batteries, and a wall charger, but you may wish to buy these components separately. The servos and receiver may not fit in a particular airplane, but a good transmitter will work with anything. You also should consider that the better transmitters remember the settings for several models (model memory).

The choice of a receiver depends mostly on the physical size and weight and number of channels for a given airplane. Micro receivers are usually single conversion and are designed for use in small airplanes that are flown close in, as the range might be affected by the low image rejection. However, there are some very small receivers, such as the seven-channel 6-meter Sombra™, and the soon to be available Berg™, both of which have DSP filtering and synthesized frequency (RF channel) selection.

This issue's column was meant to be an introduction to RC radios. In the future, I will discuss installing and setting up servos and receivers and programming RC transmitters. However, in the next column I will cover electric power systems.

73 and happy flying! Del, K1UHF

Links

http://www.airtronics.net
http://www.bergent.net
http://www.futaba-rc.com
http://www.jrradios.com
http://www.sombralabs.com

By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

RDF for the Masses
Pulsed Emitters Near 220 MHz

Visiting a high school last weekend reminded me how important the Internet has become in a relatively short time. On every bulletin board were flyers with URLs where students could find information, resources, and fun. Most of them probably can't remember a time when there was no Internet.

This month marks ten years since I put my "Homing In" website online.[1] I hoped that a site with basic information on hidden transmitter hunting would encourage more hams to try it. It would also answer the basic questions about radio direction finding (RDF) that I often received in letters and e-mails.

What I didn't expect was the number of non-hams who stumble onto the site and want to learn about RDF devices that they can use. From stolen cars to model rockets and missing children, there's a lot that people want to find and keep track of. From the beginning, I have tried to respond to every inquiry, no matter how vague or outlandish. In the process, I have learned a lot myself.

One of the first inquiries came from Tracy in Kansas, who wrote: "I have a friend who needs help with tracking his coonhounds. He says when they get out of hearing distance, it sometimes takes all night to find them. Yeah, I used to laugh too, until I heard how much money, prizes, and stud fees a good coonhound can bring in." I suspected that my leg was being pulled when I saw this postscript: "Dorothy and Toto send their love." Nevertheless, I answered as best as I could at the time.

As it turns out, Tracy was completely serious, and I discovered that a multi-million dollar market for RDF equipment has emerged among owners of hounds for sport hunting. When their dogs are following the scent of an animal such as a fox or raccoon, they may run several miles away from their owners. Radio tracking allows the humans to catch up and to round up any hounds that stray from the pack.

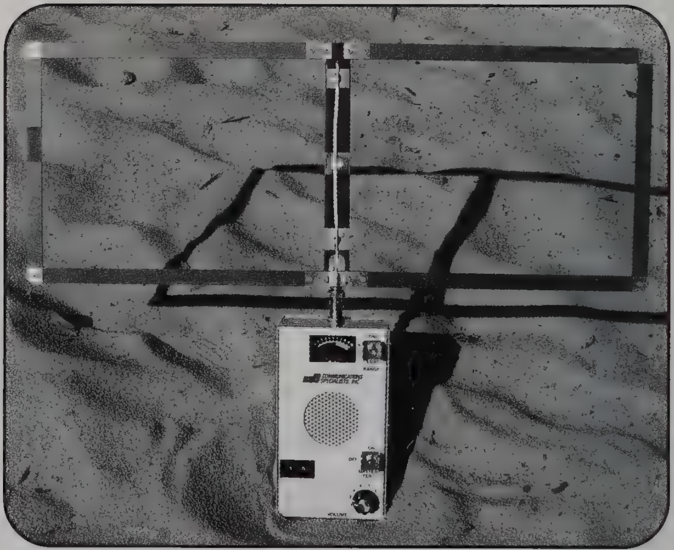
PL Boards and RDF Gear

Near the top of the list of companies riding this wave of demand for consumer RDF hardware is Communications Specialists of Orange, California.[2] This is the same ComSpec that has made subaudible tone (CTCSS) encoders and decoders for well over 20 years. However, according to owner Spence Porter, WA6TPR, "Our main business has not been building PL stuff. It's been building homing stuff."

ComSpec professional tracking receivers have been popular with wildlife researchers for decades. A photo in my "Homing In" column for Summer 2005 shows bat researcher Carl Herzog, AB2SI, programming a ComSpec Model R1000. Biologists have figured out ways to place radio tags on mammals, birds, reptiles, fish, and even insects, but growth of that market pales in comparison to the increase in individuals who want to keep track of their pets. Police and investigative agencies have an escalating need for trackers. Fliers of model aircraft and rockets are discovering RDF, too. ComSpec serves them all.

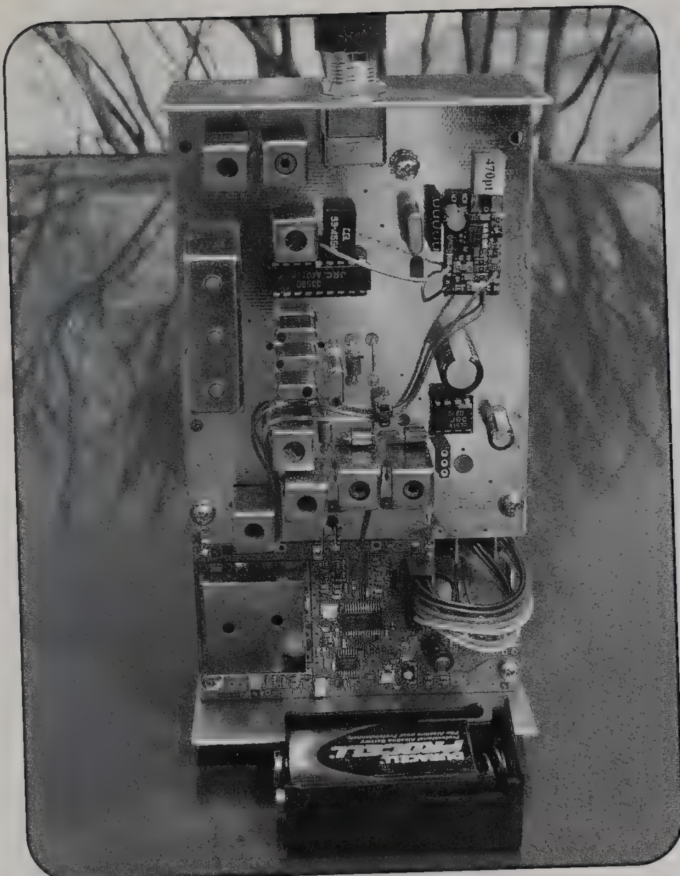
By regulation, wildlife tags must be very small and light, just a small fraction of the weight of the critters to which they are

This LoCATor pet tag weighs one-half ounce and has a breakaway link to prevent accidental choking of the animal. (All photos by Joe Moell, KØOV)



Communications Specialists PR-50 receiver and FA-1 Moxon rectangle antenna for RDF in the 218-MHz range.

*P.O. Box 2508, Fullerton, CA 92837
e-mail: <k0ov@homingin.com>



Inside view of the well-shielded PR-50 receiver. The 9-volt battery tray slides out of the bottom for rapid replacement in the field.

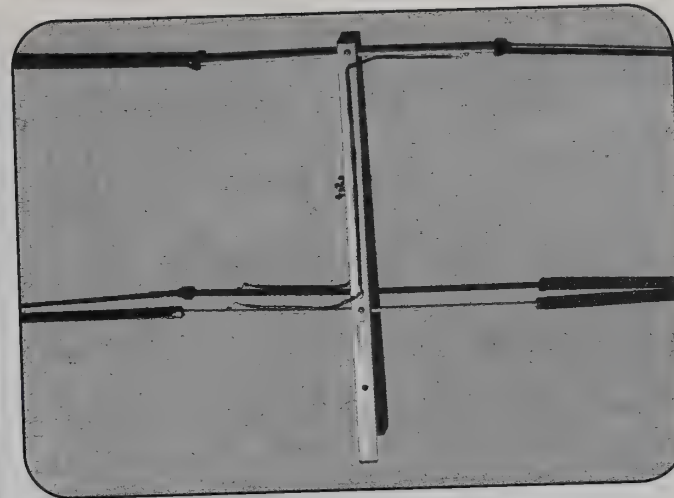
attached. They must operate for weeks or months with no opportunity for periodic maintenance. Life of their tiny batteries would be unacceptably short if radio tags transmitted continuously. Instead, they pulse on for a few milliseconds every second or so.

Until recently, almost all VHF radio tags were simple crystal-controlled "squegging" oscillators[3] that drifted in frequency as temperatures cycled and batteries aged. ComSpec met the demand for improved range and frequency stability by developing new designs with phase-locked loops and microprocessor controls. With about a half-milliwatt RF output and a 3-inch antenna, ComSpec's LoCATor feline tag can be supplied on any of 30 frequencies between 218.025 and 218.750 MHz. It is fully certified for unlicensed use under FCC Part 15. One CR2032 lithium coin-cell battery powers it for about six weeks in continuous service.

"We originally made the transmitters user-programmable with a magnet," says WA6TPR. "But that was a really bad idea. In stepping through all the channels, consumers would lose track. We had to take that feature out and simplify the manual."

The 216–220 MHz range is excellent for RDF of low-power pulse tags. There's not much interference from other services there. A quarter-wavelength transmitting antenna is only 12^3/4 inches. For the same gain and directivity, directional antennas are significantly smaller and lighter than at 150 MHz.

The peak field strength of a half-milliwatt 218-MHz LoCATor transmitter and its 3-inch antenna exceeds the 200-



The ANT1/144 two-meter RDF antenna by Ron Graham Electronics in Australia uses the classic HB9CV/PAØTBE design. Ends of the elements are sleeved flexible-tape sections that screw on and off for easy transport and safety in the brush.

microvolts/meter limits of FCC 15.209 for intentional radiators. However, it's the average that counts, and since the tags are on for just 16 milliseconds and then off for over a second, the average field strength meets FCC requirements.

In my first experience in wildlife tracking back in 1995, I found that I could detect and get bearings on desert tortoises up to about ^{3}/4 mile away with a hand-held two-element antenna. That's about the same maximum range as one will get with the LoCATor tags out in the open. In cities or the suburbs, the intervening buildings and electrical noise will reduce range to a few blocks.

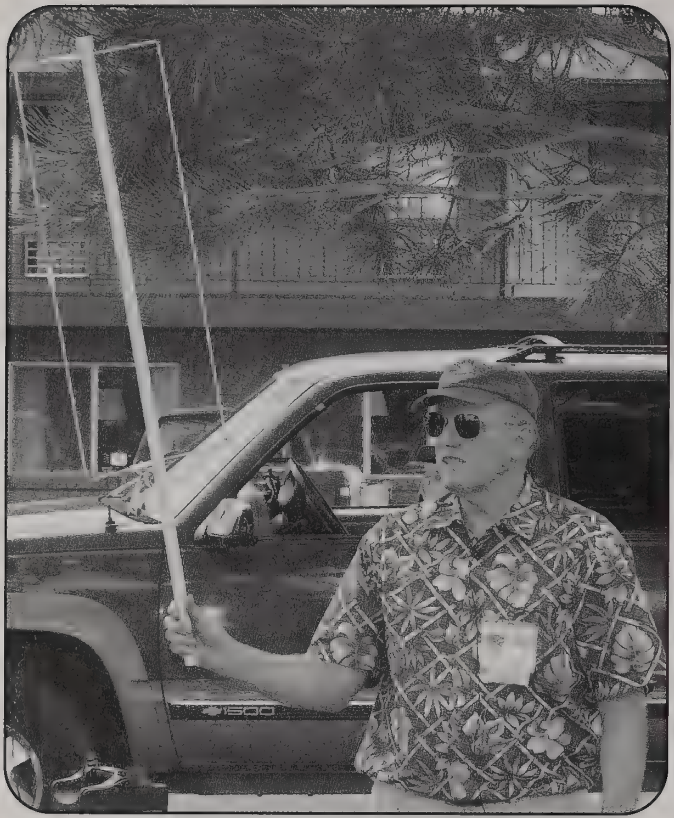
Teaching RDF to Pet Owners and Scouts

Radio tracking is easily understood by most hams, but not necessarily by the general public. According to WA6TPR, "I ran full-page ads for eight months in *Cat Fancy* magazine, and I can tell you that some people just don't get the concept. When I say the range is several blocks, they think it means just that distance from their home. I have to tell them that as their cat moves away, they can follow behind and still hear at the same relative distance. It's very simple to us, but not to every consumer."

ComSpec also sells higher power tags, including a 95-milliwatt peak model that is licensed under FCC Part 95G for law enforcement use only. It includes a strong magnet suitable for attachment to the underside of a vehicle. All transmitters are made in Spence's shop.

WA6TPR thinks that his LoCATor Part 15 transmitters would be perfect for getting Scouts and other young people to try hidden transmitter hunting. "Unlike typical ammunition-can foxes, these are really tiny and the batteries last for weeks," he says. "You could scatter a handful throughout a park and turn the kids loose."

I countered that with over a second between pulses, it might be difficult for youngsters to get bearings as they twirled an antenna around in a circle. "No problem," he replied. "I could easily change the pulse rate. The cat tags are about 50 pulses per minute to get 6 weeks of battery life. If we double or triple



At his 2005 Utah Hamfest forum, Mike Collett, K7DOU, of Layton, Utah, showed some of his RDF antenna projects, including this 2-meter Moxon rectangle that he was in the process of building.

For tracking 216-MHz pulsed radio tags in Project Lifesaver, Sam Vigil. WA6NGH, uses a three-element stiff-wire quad scaled from a 2-meter design.

that, it's almost the same as a constant carrier with a peak-reading S-meter, and their minds will easily remember which direction for best signal."

Could the cat tags be made to operate on the 125-cm ham band? "There would be no problem factory-programming to 223–225 MHz," says Spence. "All I have to do is shuffle the counters in the PLL. They're even capable of sending a periodic ID in CW. But they are already certified under Part 15 from 216 to 235 MHz, so they are legal for any use just as they are in that range, with no ID necessary."

Can't Hunt What You Can't Hear

Typical amateur radio on-foot hidden transmitter hunts have medium-power foxes with continuous transmissions of seconds or minutes. For that, an ordinary handie-talkie and an offset-type RF attenuator work very well to get bearings.[4] However, with flea-power short-pulse signals, it's another matter. It's necessary to open the HT's squelch and listen for the FM noise to be interrupted by the pulses.

The pulsed output of a wildlife tag is just like a CW dit. It's much easier to discern the dit tone of a weak tag signal on a CW/SSB mode receiver than on an FM-only receiver, where the pulse produces only momentary quieting of the noise. When combined with the narrower bandwidth of receivers designed for CW reception, the effective advantage in threshold sensitivity can be 10 dB or more.

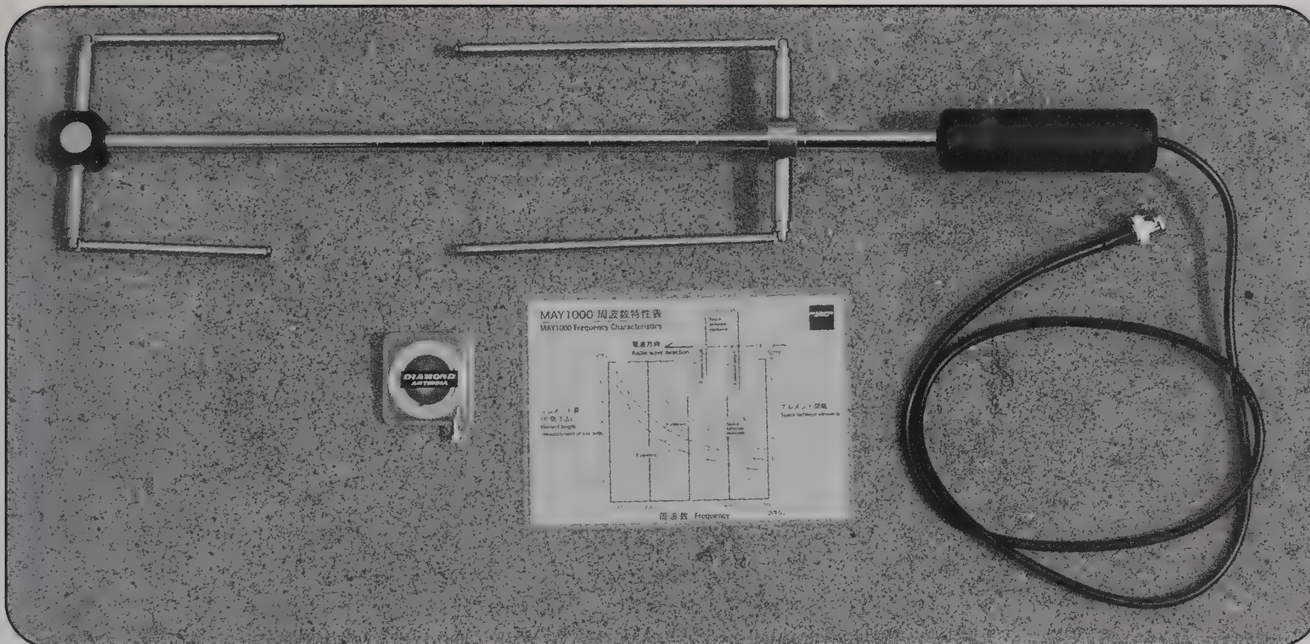
ComSpec builds the PR series of receivers, which are optimized for getting bearings on pulsed radio tags. Their sensitive front ends have helical resonator bandpass filters to eliminate images and out-of-band interference. The IF bandwidth is much narrower than the typical 12 kHz of FM receivers, giving the PR receivers better signal-to-noise ratio on unmodulated pulses.

Figure 1 lists my threshold sensitivity measurements of some typical scanners, ham receivers, and the ComSpec PR-50 receiver. Values in the table are RF input in nanovolts and in dB with respect to one volt for the weakest signal that could be detected and tracked. All measurements were on tag channel 10 (218.025 MHz), except for the IC-03A, which was measured on 224 MHz.

My data show that the PR-50 has a 3-dB advantage over the second-place receiver and 14 dB over a typical NBFM scanner. Each 6-dB increase in sensitivity translates into about twice the tracking range in open country, all other factors being equal.

Mfr.	Model	Mode	dBv	Nanovolts
CommSpec	PR-50	CW	–152	25.1
Kenwood	TH-F6A	CW	–149	35.5
ICOM	IC-R10	CW	–145	56.2
ICOM	IC-03A	FM	–144	63.1
Kenwood	TH-F6A	FM	–139	112.2
ICOM	IC-R10	FM	–138	125.9

Figure 1. Threshold sensitivity comparison of receivers for pulsed-signal RDF near 220 MHz.



The MAY1000 handheld two-element Yagi by Diamond Antenna telescopes and folds for storage. It comes with a frequency chart and measuring tape.

For closing in, RF attenuation is built into PR-series receivers, with a three-step range switch and gain control. A $1^{3}/4$-inch speaker puts out lots of sound. The peak-reading meter makes it easy to distinguish signal-level changes of pulsed emitters while turning the antenna. Frequency control is channelized and the range of frequencies depends on the model.

The only disadvantage I noted is that at 1.3 pounds, a PR-series receiver is bigger and heavier than most imported handheld receivers. That might be problematic for use by a pack of Cub Scouts. A pistol-grip handle underneath at the balance point would make it much easier for pre-teens to carry.

The H, the Rectangle, and the Quad

Wildlife researchers have found that two-element beams are just right for on-foot field tracking, a good compromise between size and gain. Most popular among them is the compact HB9CV type, which they call the "H Antenna" because it's shaped like that letter. The HB9CV beam is an adaptation of the classic "ZL Special." The VHF version is attributed to Jan Jager, PAØTBE. Its two elements are fed out of phase with gamma matches on each to achieve excellent directivity with short spacing (0.12 wavelength).

Telonics, Incorporated is one of the most popular suppliers of H Antennas to the research market.[5] Telonics HB9CV beams feature wooden handles so that users can hold them high overhead with horizontal polarization while getting bearings. A HB9CV RDF antenna for 2 meters is sold by Ron Graham Electronics in Australia.[6]

An even more compact RDF antenna is the Moxon rectangle, originally developed by Les Moxon, G6XN. It is basically an enhanced two-element Yagi. Ends of the driven element are folded toward the reflector at about 0.18 wavelength from the feedpoint. Ends of the reflector are folded toward the driven element at the same distance from center. The gap between the driven element and reflector tips is critical. When it's optimized, the Moxon has a broad forward lobe, a deep rear lobe, and nearly perfect feedpoint match to 50-ohm coax.

Typical VHF Moxon rectangle dimensions are 0.36 by 0.15 wavelength. ComSpec's Model FA-1 RDF antenna, supplied with PR-series receivers, is a 8" × 20" Moxon made from strips of printed-circuit-board material. A wealth of information on Moxon antenna design and construction is available on the web.[7]

CQ National Foxhunting Weekend is Almost Here

Whether you prefer to fly the freeways or beat the bushes in search of hidden transmitters, be sure to get together with other hams in your locality for foxhunting fun during the 9th annual CQ National Foxhunting Weekend (NFW). On May 13–14 ham clubs and non-club groups across the country (and elsewhere in the world) will hold mobile and on-foot RDF contests.

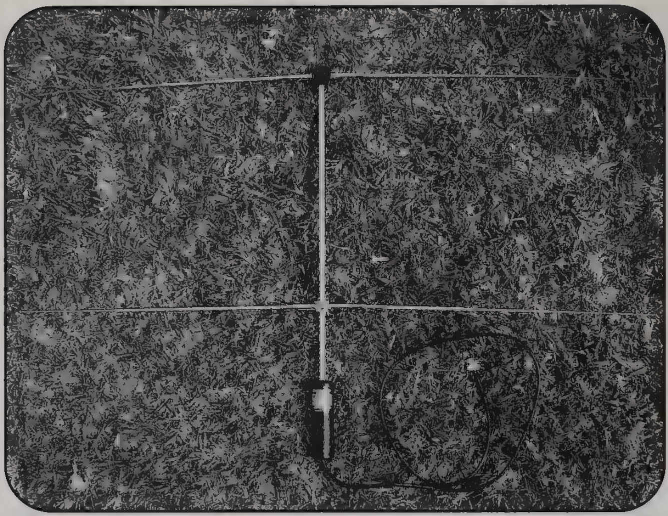
If there has never been a hunt in your area, or if it has been a while, have a simple one to get maximum interest and participation. If RDF is already a regular activity, try something new and be sure to encourage members who have not participated before.

If an all-on-foot hunt is your club's choice, make sure that the kids, grandkids, nieces, and nephews of all members are invited. They don't need driver's licenses or ham licenses to receive and hunt. It's a great way to show them that ham radio is more than HTs, computers, and QSL cards.

There are no formal rules for the NFW. You can be as creative (and sneaky) as you like, as long as your hunt is fair and safe for everyone. You don't even have to schedule it on May 13–14. Any weekend in the spring will be fine! For some ideas, read the results of last year's NFW in the May 2006 issue of *CQ* magazine. You can also read more about the NFW and this year's major ARDF events in my article "It's Radio Foxhunting Season" in the April 2006 issue of *CQ*.

After your hunt, be sure to write up the results and send to me, along with some candid photos of the hiders and hunters. Maybe your story will be included in my follow-up article.

Joe, KØOV
CQ NFW Moderator



The MAY1000 handheld two-element Yagi adjusted for RDF at 218 MHz. It can be set to any frequency from 120 to over 500 MHz.

For more gain, the popular "measuring tape" three-element Yagi design of Joe Leggio, WB2HOL,[8] could be readily scaled to 218 MHz. Cubical quads are small enough for hand-held use at 218 MHz, too. Back when there were monthly southern California T-hunts on the 222-MHz ham band, I found many of them with a stiff-wire quad scaled from a popular 2-meter design.[9]

An advantage of the stiff-wire quad over quads with thin wire strung between spreaders is that the stiff-wire quad better survives rough use in the field. If it gets a little bent up, it's easy to bend it back into shape. Sam and Eve Vigil (WA6NGH and KF6NEV) are using such a quad for tracking 216-MHz radio tags as part of Project Lifesaver.[10] They even have used this quad to get bearings from the San Luis Obispo County Sheriff's helicopter.

Whether you're seeking radio foxes, Alzheimer's patients, your pet, or your model airplane, I want to hear and share your experiences with tracking miniature pulsed transmitters. What are you doing to optimize your range and bearing accuracy? Drop me an e-mail or postcard at the addresses on the first page of this column.

New Frequency-Agile RDF Antenna

About five years ago, I was talking to an FCC engineer who wanted to know where to buy a hand-held RDF beam that was usable over a very wide frequency range, to complement his existing wide-range mobile-mounted RDF equipment. He didn't need wideband or spread spectrum signal-tracking capability; he just wanted to be able to adjust the beam to any UHF or VHF spot frequency where spurious signals or other problems might be occurring. I agreed that it would be very useful to have such a beam, and I would buy one myself.

In years past, FCC had obtained some three-element Yagis with large, square, slotted booms and telescoping elements that would slide in the slots along the boom. Director and reflector could be locked in place at just the right location to provide maximum gain and front/back ratio at the frequency of interest. Those clunky antennas had fallen into disrepair and were no longer procurable.

Each of us inquired at some machine shops, but none of them were interested in tooling up to make clones of those antennas in the small quantities that would be procured. However, the engineers at Diamond Antenna must have read our minds. Diamond's new MAY1000 Handheld Beam[11] does everything that we were seeking, and it's better designed than the FCC's old beams. It features two folding and telescoping elements. The driven element is fixed at the front end of the boom, while the reflector position is adjustable on the boom to optimize gain and front/back ratio at the receive frequency.

It only takes a minute or two to set up the MAY1000 before use. Fold out the elements, which automatically lock into place with spring collars. Slide and secure the reflector onto the boom at about 0.2 wavelength from the driven element. Pull out the telescoping driven element halves to 0.25 wavelength on each side. Pull out the reflector halves to 0.28 wavelength on each side.

You don't need a calculator, because Diamond supplies a card with curves showing the optimum element lengths and spacing in centimeters versus frequency. A metric tape measure is also included. It's best to use the values from the card, because they are optimized for gain, front/back ratio, and feedpoint impedance at each frequency, taking element diameters into account. For instance, best spacing is 0.233 wavelength at the high end of range and 0.175 wavelength at the low end. Using the graph values, SWR is specified to be 1.5:1 or better at any frequency from 120 to 500 MHz.

Besides being another way to track those pulsed radio tags from 216 to 225 MHz, the MAY1000 can be used in the aircraft band, three VHF/UHF ham bands, and everything in between. The elements telescope down to $4^1/2$ inches on each side, so operation up to 600 MHz ought to be possible with somewhat degraded SWR.

Is this the only hand-held RDF antenna you'll ever need for VHF/UHF? Maybe not, because it isn't suitable for crashing through the brush. It's made from stainless steel and won't break easily, but for the woods, I prefer elements that give way for safety and speed. A tape-measure beam or stiff-wire quad would be better for that.

The MAY1000 has only the gain and directivity of a two-element Yagi, so you'll need a longer-boom antenna for maximum range. For rapid setup to hunt a signal anywhere it its wide frequency coverage, though, this Diamond antenna is hard to beat. I wonder how many the FCC has ordered.

73 and happy hunting, Joe, KØOV

Notes

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10. Ostapchuk, "DFing a Lifesaving Transmitter," *CQ VHF*, Winter 2005
11. <http://www.rfparts.com/diamond/MAY1000.html>

By Bob Witte,* KØNR

FM/Repeaters—Inside Amateur Radio's "Utility" Mode

Rack Mount Your Portable Station

A portable ham station comes in handy for many VHF radio activities: public-service events, emergency communications, vacations, VHF contests, and more. Here are some ideas on how to construct a portable ham station using rack-mount equipment.

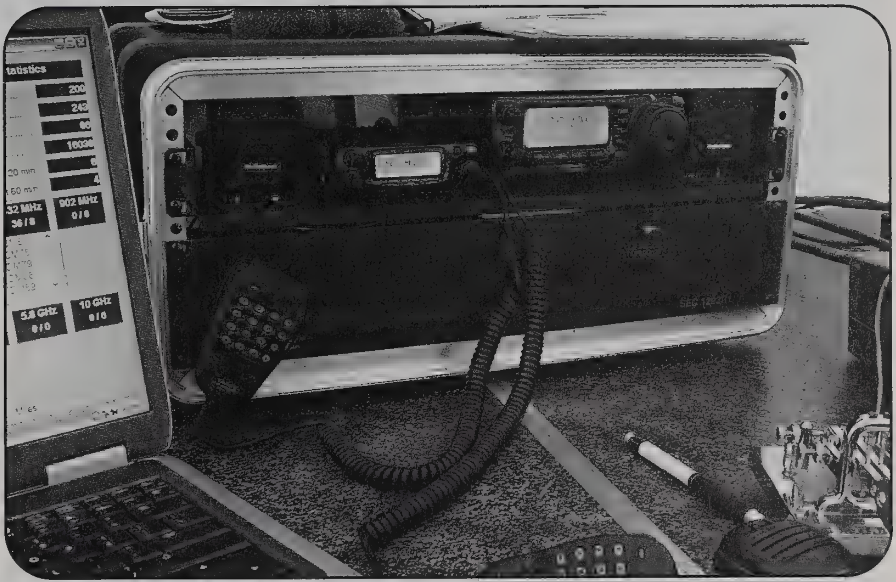

Photo 1. The KØNR portable station with the Yaesu FT-90 and FT-100 transceivers.

The summer of 2002 brought a series of wildfires to the western U.S., including the Hayman Fire, the largest fire in the recorded history of Colorado. As part of the ARES support, I found myself operating my FM VHF station portable from a county fire station. My setup was typical of many such situations: an FM VHF rig fed by an AC power supply, connected to an antenna that was previously installed at the fire station. The rig was just lying on a table with the power supply next to it. There was no specific place for the microphone, so it also ended up lying on the table, too. I tried to prop up the radio so that it was easier to read the display, but it was not that great—functional, but not great. When the radio traffic slowed, I found myself looking at the pile-o-stuff and thinking that there had to be a better way.

Ultimately, this resulted in the creation of a portable ham station that has many uses (photo 1). My basic requirement was to have two transceivers, both covering 146 MHz and 440 MHz FM, as both bands get used during ARES deployments. Also, it is very handy to be able to monitor more than one frequency at a time, even on the same band.

I had a spare Yaesu FT-90 dualband (single receiver) transceiver and I acquired a Yaesu FT-100 HF/VHF/UHF rig. The FT-100 might be a little bit of overkill, but I liked the idea of having the CW/SSB modes on 6 meters, 2 meters, and 70 cm for VHF contesting. Including the FT-100 as the second radio gave me those modes, while tossing in the HF bands for free.

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I've used this portable station for public-service events, emergency communications, Field Day, and VHF contests. It also makes a decent home station, one that can be moved from room to room as required. My purpose in writing about this is not to have you replicate the same thing, but to provide some ideas on how you might create a portable station tailored to your needs.

The 19-inch Rack Box

I had been looking for a good way to mount equipment in a box so that it would be protected and portable. I discovered some equipment boxes that are designed around a standard 19-inch rack. These boxes are used in applications such as sound recording and live music. Your local disc jockey who provides music for parties is likely to have a rack like this. A protective cover latches onto the front of the box, and a carrying handle is molded into the enclosure (photo 2). I have encountered two manufacturers of these rackmount boxes, SKB and Gator (see references for web addresses). These should be available at your local music store, or on the web at Musicians Friend and Sweetwater Sound.

The 19-inch rack concept is based on an Electronics Industry Association (EIA) standard, so there is a quite an array of equipment and accessories available in this format. As the name implies, the hor-

Photo 2. The rack-mount box comes with a protective cover and carrying handle, making it easy to carry and transport.

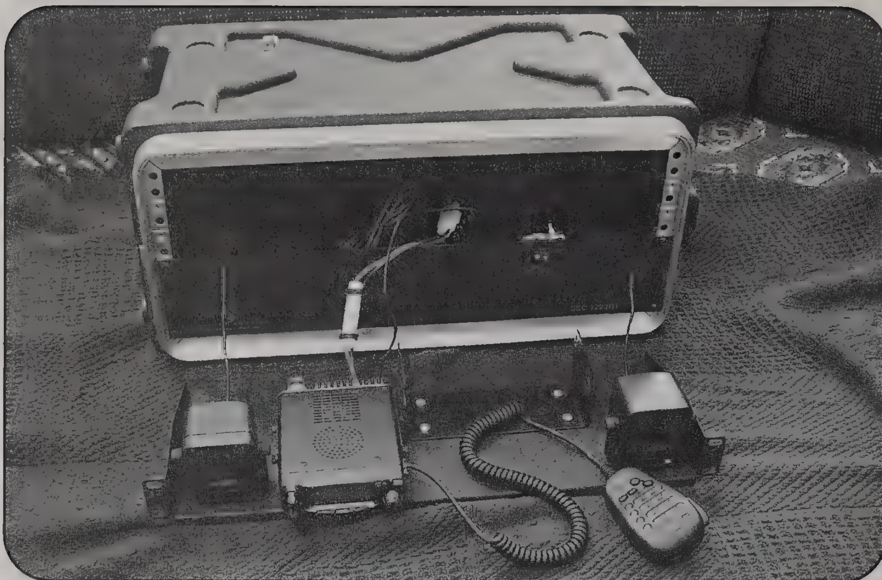

Photo 3. The two ham transceivers are mounted using a standard rack shelf.

izontal spacing of the rack is 19 inches. The vertical spacing is normally specified in multiples of 1.75 inches, which is referred to as a standard unit, or "U." Therefore, a 1-U high component occupies 1.75 inches of rack space, while a 2-U high component occupies $2 \times 1.75 = 3.5$ inches. The box I used is 4-U (7 inches) high, also referred to as a "4 space" rack.

The KØNR Station

My approach was to use as many standard rack-mount parts and as much standard equipment as possible. There are a number of power supplies available in a 19-inch rack format, from suppliers such as Astron and Samlex. I chose to use a Samlex SEC 1223R1 power supply. Ham radio equipment usually does not come configured for rack-mount installation, so I used a rack shelf to mount the transceivers (photo 3). The standard mobile mounts for the radios were easy to attach to the shelf using a few machine screws and nuts.

I was concerned about having sufficient audio coming out of the station. I installed two forward-facing RadioShack communications speakers (RS# 19-318), one for each radio. The idea is to direct the audio right to the operator and not rely on the internal speaker of the transceiver, which is facing upward inside the rack. The speakers are separated right and left so the operator can easily associate the audio with the appropriate radio.

I've also found that headphones are a very useful feature when doing emergency communications, so I included a stereo headphone jack (photo 4). I considered a number of different ways of wiring the headphones, but ended up with a relatively simple approach. The headphone jack is wired with the left radio in the left ear (only) and the right radio in the right ear (only). This maintains the natural separation of the radios so that when both of them are receiving a signal, the operator can keep them straight. The headphone jack is fed from the transceiver external speaker jacks and is live all of the time. A speaker on/off switch controls whether the audio also gets routed to the external speakers. This allows the speakers to be turned off in situations in which the sound is distracting to other people in the area. I mounted the headphone jack and switch by drilling holes in the plastic case. The rack box is made of relatively soft plastic, so this is easy to do.

Power

Any time the subject turns to portable operation, the power source is a major consideration. Should the power system be set up for 12 volts DC, 120 volts AC, or both? For emergency use, it makes sense to have a battery as a power source so that the station can operate independent of commercial power. This leads to the question of how much battery capacity is required. Ideally, it would be great to be able to operate for several days without AC power, but this requires a large battery, which would make the box larger and heavier. Another approach is to design the station around 12 volts DC and provide an external battery for power.

Photo 4. The KØNR station has a headphone jack and a switch that controls whether the external speakers are on or off.

Photo 5. A feedthrough connection on the top of the box provides a place to connect VHF antennas.

I decided to include an AC power supply in the station to power the transceivers (which, of course, operate on 12 VDC). When AC power is available, it is the easiest way to supply power to a portable station. It makes sense to use the AC rather than deal with the battery charging and maintenance issues. (My experience is that the battery will go dead just when I need it most.) For extended operation, I own a gasoline electric generator, an efficient way to provide AC power for extended periods of time.

Switching power supplies are much lighter in weight and more compact than the traditional linear supplies,

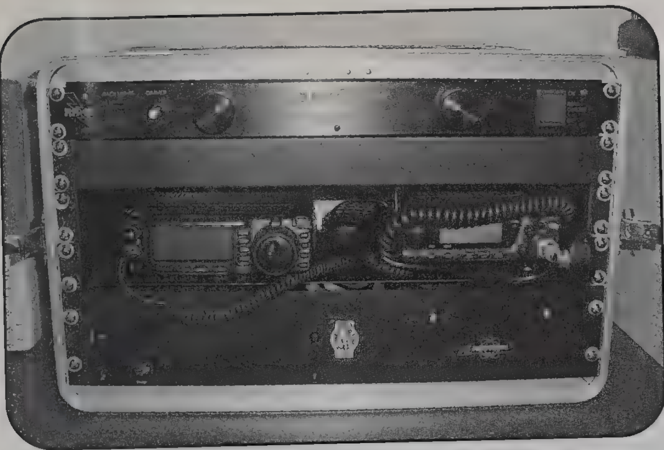

Photo 6. The two-transceiver KA5CVH portable station uses an Astron power supply and an AC power distribution strip. (Photo courtesy of KA5CVH)

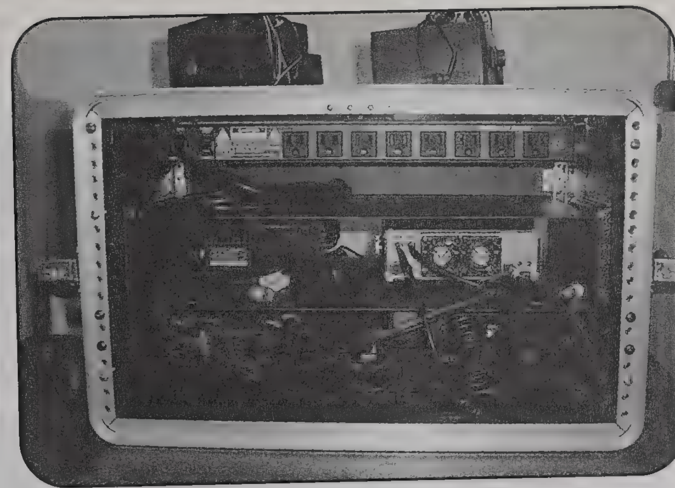

Photo 7. Rear view of the KA5CVH station. (Photo courtesy of KA5CVH)

making them the obvious choice for a portable station.

I also made provision for disconnecting the AC power supply and running off an external battery or 12-VDC source. The DC power is distributed via an MFJ-1117, which is basically a box with four pairs of heavy-duty binding posts. This is not the most elegant solution for routing DC, but it can easily be reconfigured to meet almost any need.

Antenna Connections

The back of the rack box has a removable plastic panel that allows access to the back of the transceivers. My antenna connection scheme is simply to open the back panel and connect to the antenna ports on the radios. I also installed a PL-259 style feedthrough connection on the top of the box (photo 5). I connect a PL-259-to-BNC adapter and a VHF/UHF whip antenna (BNC connection) to this feedthrough. This is a simple, compact method of getting the station on the air.

Photo 8. The NC6T portable station includes four transceivers and an SWR meter. (Photo courtesy of NC6T)

KA5VCH Station

Recently, I discovered two other hams who have used the same basic approach for creating a portable station. Both Christopher Taylor, NC6T, and Mike Urich, KA5CVH, have portable stations based on the same type of rack-mount box. The KA5CVH station is very similar to mine, employing two transceivers but in a slightly larger rack (photo 6).

Mike chose a rack made by Gator that has rack-mount rails on the front and back of the rack (photo 7). This provides a larger rear-panel opening than the box I used, providing easier access. It also makes the rear of the box more useful in terms of mounting equipment. For example, Mike has experimented with mounting the power supply on the rear rails to balance the weight more effectively.

Mike used a rack-mount power conditioning strip (a RackRider RR-15), which provides a front-panel power switch, circuit breaker, and MOV transient/surge protection. The RR-15 also provides lighting for the front of the rack, complete with dimmer control, which is a handy operating aid for dimly lit environments. A careful look at photo 6 reveals that Mike added a toggle switch to the front panel of the power supply that switches between using the AC supply and an external DC power source. The chassis of the Astron power supply occupies a little less than half the rack width, so the rest of the space behind the rack panel is open, which makes it a convenient place to mount switches or other devices. Mike has a number of photos of his station on his website, so be sure to check that out.

NC6T Station

NC6T's station has four transceivers, including a 222-MHz FM rig and a 2-meter rig for packet (photo 8). Two of the rigs are FT-7800 VHF/UHF transceivers,

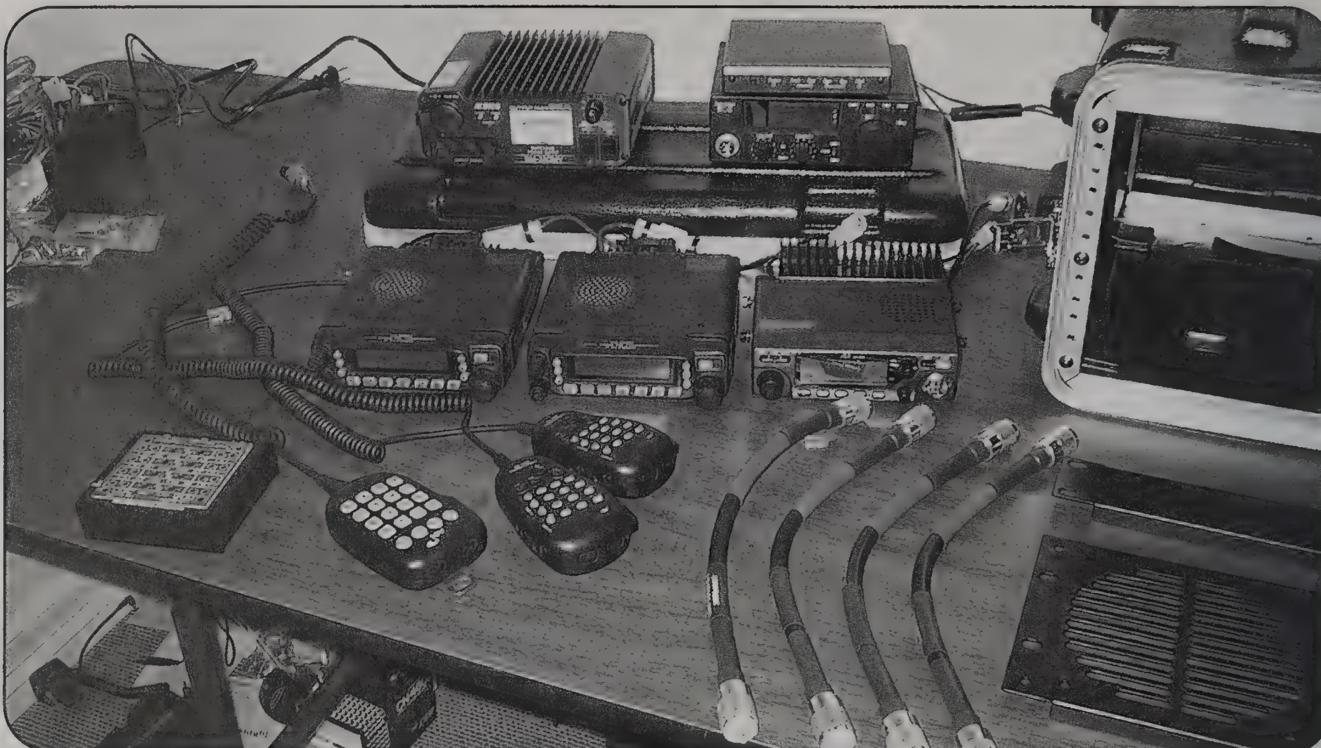

Photo 9. The NC6T portable station equipment, disassembled and displayed on a table. (Photo via NC6T)

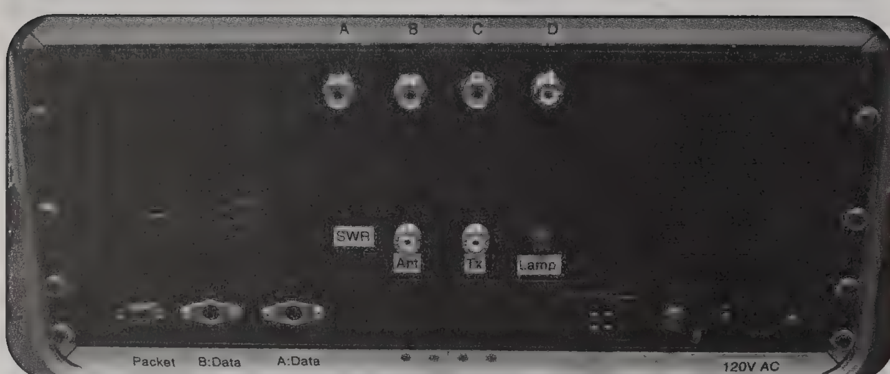

Photo 10. The NC6T rear panel has feedthrough connections for antennas (labeled A, B, C, D), data, and power connections. (Photo via NC6T)

which have their microphone connectors on the side of the radio, so Christopher extended the microphone cable out to the front for easy access. This allows all three voice rigs to have their microphones removed for transportation. Christopher chose to use a compact Alinco power supply, rather than a rack-mount supply. This makes the mounting slightly more difficult, but it takes up less space, especially the front-panel area.

With four rigs to contend with, NC6T did a nice job of labeling the radios. He also included an SWR meter for making antenna measurements. The "exploded view" of the NC6T station is shown in photo 9.

Christopher also used a rack that has rails on the rear panel, which he used to mount two panels for connector mounting (photo 10). The four antenna connections are labeled A, B, C, D across the top of the panel. The connections to the SWR meter are brought out to the rear panel so that any of the four antennas can be checked using a short jumper coax. Data connections to the two Yaesu rigs and the serial port for the packet station are shown in the lower left. At the lower right is a standard AC power-cord receptacle, which is connected to the Alinco power supply. Christopher also has Anderson power-pole connectors for supplying 12 volts DC to the station. A large toggle switch selects either AC or 12-VDC power for the station.

Acknowledgments

Special thanks go to Mike, KA5CVH, and Christopher, NC6T, for sharing their ideas and photographs of their portable stations. If you have additional ideas, drop me an e-mail telling me what you have tried. I know this is not the first (or last) portable VHF station to be constructed.

Thanks for reading the column, and check out my webblog at <k0nr.blogspot. com>.

73, Bob, KØNR

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SKB Cases: <http://www.skbcases. com>
Musicians Friend: <http://www.musiciansfriend.com>
Sweetwater Sound: <http://www.sweetwater.com>

CQ's 6 Meter and Satellite WAZ Awards

(As of April 1, 2006)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones needed to have all 40 confirmed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23,24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19.23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	2,16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25,28,30,31,32
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	1,10,18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,10,12,18,19,23,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24.26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	KØSQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IKØPEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28
72	K4MQG	17,18,19,21,22,23,24,25,26,28,29,30,34,39
73	JF6EZY	2,4,5,6,9,19,34,35,36,40
74	VE1YX	17,18,19,23,24,26,28,29.30,34
75	OK1VBN	1,2,3,6,7,10,12,18,19,22,23,24,32,34
76	UT7QF	1,2,3,6,10,12,13,19,24,26,30,31
77	K5NA	16,17,18,19,21,22,23,24,26,28,29,33,37,39

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. In 2001 we "lowered the bar" from the original 40 zone requirement to encourage participation in this very difficult award. A Satellite WAZ certificate will indicate the number of zones that are confirmed when the applicant first applies for the award.

Endorsement stickers are not offered for this award. However, an embossed, gold seal will be issued to you when you finally confirm that last zone.

Rules and applications for the WAZ program may be obtained by sending a large SAE with two units of postage or an address label and $1.00 to the WAZ Award Manager: Floyd Gerald, N5FG, 17 Green Hollow Rd., Wiggins, MS 39577. The processing fee for all CQ awards is $6.00 for subscribers (please include your most recent *CQ* or *CQ VHF* mailing label or a copy) and $12.00 for nonsubscribers. Please make all checks payable to Floyd Gerald. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. N5FG may also be reached via e-mail: <n5fg@cq-amateur-radio.com>.

**17 Green Hollow Rd., Wiggins, MS 39577; e-mail: <n5fg@cq-amateur-radio.com>*

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

SuitSat, Expedition 12 Activity on the ISS, CubeSats, and more

Since the last column, SuitSat was deployed on February 3, 2006; Expedition 12 continues to be *very active* on the ISS (International Space Station); more CubeSats have been launched; the site that had been chosen (but was changed) for the the 2005 AMSAT Space Symposium was visited during the annual Acadiana Amateur Radio Club Hamfest in Rayne, Lousiana; and working AO-51 mode V/S in the rain at the Green Country Hamfest became a "team effort."

SuitSat

SuitSat was deployed on February 3, 2006 via an EVA (extra vehicular acivity) from the ISS. The successful deployment received unprecedented coverage in all branches of the media. Unfortunately, a problem developed with the signal strength from SuitSat and only large EME class stations were successful in copying much data. Everything in SuitSat worked, but the signal was approximately 30 dB weaker than planned. After an initial "scramble" to hear anything, telemetry was captured from about February 8–17. Nothing has been heard since February 18, and the batteries are presumed dead. The voltage dropped rapidly from about 26 volts to 18 volts before it went off of the air. As far as we know (as of March 27), SuitSat is still in orbit, but it has to re-enter soon.

Even with the low signal level, SuitSat is considered to be a success. It has shown what can be accomplished in a fairly short time with some imagination and a lot of hard work.

Expedition 12 Activity on the ISS

The Expedition 12 crew—made up of Bill McArthur, KC5ACR, Commander, and Flight Engineer Valery Tokarev—has been very active on the ISS. School contacts have been scheduled at two a week, and general operations have been greatly increased. More than 35 school contacts have been made. SuitSat has been assembled and deployed. Bill has now worked WAC on both VHF and UHF, WAS, and DXCC while on this mission. Many amateur radio operators can now say they have worked the ISS and done so with very modest stations.

CubeSats

Cute 1.7 was launched by the Japanese during this period and is doing well. Several earlier CubeSats, plus SuitSat, have now been given OSCAR numbers, and the latest is CUBESAT-OSCAR-58, or CO-58. Many more are in the works. We were treated to a display of hardware and a talk about the CubeSat project by student builders from the University of Louisiana at Lafayette during the annual Acadiana Hamfest in Rayne, LA. They are looking forward to a launch from Russia in May 2006.

SuitSat-1 ready for deployment. (Photo courtesy of NASA/ARISS)

Visit to Lafayette, LA

During March, Roger Ley, WA9PZL, and I made our annual trek to the Acadiana Hamfest. Rayne is a small town just west of Lafayette, LA, which was to be the location of the 2005 AMSAT Space Symposium until the effects of Hurricane Katrina forced its cancellation. I'm happy to report that the area has now recovered and is largely back to normal. The crawfish crop was affected somewhat, and there was a temporary shortage of it for the annual Crawfish Boil. Roger and I waited too long to get in line and missed ours. We thus were forced to exist on the excellent shrimp etouffee, jambalaya, and gumbo made by the Rayne High School Scholarship Fund group. Tough duty indeed!

This has always been one of my favorite hamfests, and this year was no exception. Hopefully, we will be able to re-sched-

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ule the AMSAT Space Symposium back into this area in the future—possibly 2007.

Working AO-51 Mode V/S by Team Effort

March is a busy month for hamfests. My second one for the month was the Green Country Hamfest in Claremore, Oklahoma. This is an excellent hamfest that has grown every year since it moved out of downtown Tulsa and into the Claremore Expo Center. The only problem this year was rain. It looked like the rain was going to prevent my usual satellite demonstrations, but it "slacked off" a little bit and I decided to go ahead with an attempt for AO-51 Mode V/S. Partial cover was provided by the rear door of my mini van. The van also provided power for the S-Band to 2-meter down converter.

Two more brave souls decided to observe the attempt, and I put them to work. I held the S-Band antenna and down converter, along with the Yaesu FT-817 that was pressed into service as the 2-meter IF. I also assumed the duty of keeping the 817 tuned for the ±50 kHz of Doppler. One of the other fellows held the Arrow Antenna and kept it pointed in the general direction of the S-Band antenna. The third team member operated the Kenwood TS-D7 HT and did the talking. All of this effort was expended while trying to keep the radios as dry as possible in the light drizzle.

We did succeed in being recognized by the gang on the bird and made at least a half-dozen contacts during the 70-degree elevation pass. Not bad for a team effort in the rain! We did cancel the VO-52 listen-only demo to allow time to dry out the equipment and get ready for the AMSAT forum. As this is being written, it is next on to Weatherford, Texas to round out my attendance at March hamfests for another year.

Summary

As usual, there are satellite activities to keep you busy at any time of the year if you look for them. Bill McArthur, KC5ACR, and his efforts on board the ISS certainly will never be forgotten. However, Expedition 13 is waiting in the wings and will start with a trip to the ISS for the new crew this week (on March 30). Please support your area hamfests, and by all means, support the efforts of AMSAT to build our new projects—Phase 3E and Eagle. 73, Keith, W5IU

By John Champa,* K8OCL

Communicating Voice, Video, and Data with Amateur Radio

The Hinternet and openHSMM Plus Experiments on 6 Meters

This month's column is guest authored by Paul Pescitelli, K4UJ, Assistant Emergency Coordinator, Gwinnett County, Georgia ARES. Paul is also the ARRL HSMM Working Group Project Leader for the openHSMM Project. He may be reached at: <dx.k4uj@gmail.com>.

The term "openHSMM" is derived from the combination of Open Source software and High Speed MultiMedia. Open Source software was designed to meet some of the goals of the ARRL's High Speed MultiMedia (HSMM) Working Group, chaired by John Champa, K8OCL. The intent of the working group is to research and implement new technologies in high-speed digital signaling networks.

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Design Criterion

The openHSMM-ap design criterion is to create a wireless-access-point appliance that contains features found in wireless access points that are commonplace today. Why re-invent the wheel? Today's consumer-grade access points lack two very important features that are necessary to create flexible wireless networks.

First, the deficiency lies in the radios. Consumer-grade access points traditionally have relied on a single radio to provide connectivity. While efficient in their design, they cannot provide the diverse connectivity options that may be required, especially in an unplanned environment such as those found during emergency communication deployments. Sometimes 802.11b works well, but it would be good to provide alternatives, such as 802.11a or 900-MHz WiFi for creation of backbones. This is one area that openHSMM hopes to address in the coming months.

The second deficiency is the lack of true networking protocols. In order to create a scalable network (wired or wireless), it would be beneficial to provide configuration options such as OSPF (Open Shortest Path First). OSPF is a tried-and-true routing protocol that broadcasts its routes to

League Requests Rule Change to Ease Spread Spectrum Operation

The following is from the *ARRL Letter*:

The ARRL has asked the FCC to modify one of its rules governing spread spectrum (SS) operation on amateur radio frequencies. The League has petitioned the Commission to drop all but the first sentence of §97.311(d), which now requires the use of automatic power control (APC) for SS stations running more than 1 W. The ARRL request would retain the 100 W overall power limitation for SS.

"The effect of the rule change would be to eliminate an automatic power control provision that has proven over time to be impractical" in terms of compliance, the League said in its Petition for Rule Making filed March 13. It also conceded that the provision—one the League had proposed and supported more than 10 years ago—was unnecessary to protect the operations of other licensees and had "unfortunately served as an unintended but effective deterrent to spread spectrum experimentation" on ham radio.

Since the FCC first approved the use of spread spectrum techniques for amateur radio in 1985 on bands above 225 MHz and at power levels up to 100 W, there's been limited—but never widespread—experimental amateur operation. More recently, the FCC has made the SS rules less restrictive in response to League showings that the rules were hampering SS experimentation and that interference has not proven to be an issue.

The ARRL says it now agrees with those who opposed the automatic power control provision in WT Docket 97-12, concluded in 1999. Those changes not only relaxed rules governing the use of spread spectrum techniques by radio amateurs, but opened the door to the possibility of international spread spectrum communication.

"Now seven years later, it is apparent to ARRL that the rules requiring APC indeed have proven to be difficult to implement, unnecessary, and something of a barrier to SS experimentation," the ARRL said in its latest rule making petition. "Section 97.311(d) can be greatly simplified without increasing the risk of intra-service or inter-service harmful interference."

The ARRL said keeping the maximum power at 100 W limits the power spectral density of an SS emission, contributing to compatibility between amateur radio SS and narrowband modes in the same allocations. The rules already in place make spread spectrum "essentially secondary to any amateur narrowband emission modes," the League pointed out, and make the APC requirement unnecessary to avoid interference to other users of the same spectrum.

In any event, the League concluded, radio amateurs employing SS modes would remain obliged to comply with the rule requiring use of "the minimum transmitter power necessary to carry out the desired communication." That was a primary reason the ARRL asked for the APC provision in the first place.

The FCC has not yet assigned a rule making (RM) petition number to the ARRL's petition nor invited comments.

In its Notice of Proposed Rule Making (NPRM) WT Docket 04-140, the FCC, in response to another ARRL petition, proposed extending the bands available for spread spectrum to include 222–225 MHz. On its own initiative, the Commission also recommended permitting SS operation on 6 and 2 meters, a move the ARRL opposes. In its comments, the League cited concerns about raising the noise floor on 6 meters and the fact that both bands already support substantial narrowband and weak-signal work, meaning "fewer opportunities for frequency reuse in those allocations."

The Commission is expected to conclude WT Docket 04-140 this year. The FCC suggested that restrictions on spread spectrum already in place should be sufficient to prevent any adverse impact of SS operation to other users of 6 and 2 meters.

Experiments on 6 meters

By John Champa, K8OCL

It's official! The FCC has issued an Experimental Special Temporary Authorization for the ARRL HSMM Working Group to conduct experiments on the 6-meter band. Thanks to help from the League's CTO, Paul Rinaldo, W4RI, callsign WC9XLP has been issued to John Stephensen, KD6OZH, in the San Joaquin Valley, Fresno, California. John is the Working Group's HSMM-VHF Project Leader.

The experiments will be conducted appropriately in the 50.3–50.8 MHz range with a maximum authorized power of 1.5 KW (ERP) using Orthogonal Frequency Division Multiplex (OFDM) modulation. This is modulation similar to that used with 802.11g, but employing much narrower bandwidth. It is hoped that the Working Group will be able to achieve a data rate as high as 240 kbps while occupying a bandwidth of no more than 200 kHz.

These digital test signals essentially will be on a non-interfering (no QRM) basis. First, they are spread out over as much as 200 kHz of bandwidth. With such low power density, it is *not* likely that they would be detectable on an FM receiver. If they can be detected at all, it might be with an SSB receiver, and then only as very faint background noise.

According to John, KD6OZH, "The 6-meter antenna is up *(it's a monster; see photos—ed.),* so I'll be able to try low-frequency HSMM soon. I've also attached a graph of troposcatter loss. The 50-MHz band is our best bet for long paths, as losses increase by the cube of the frequency. However, losses are high, so 50–100 km is probably the limit with the equipment that I have. The use of 1500 watts PEP and four long Yagis should allow 20 dB more path loss for a 200–250 km range, but it wouldn't be very portable (see picture from M²). This is all speculation, as I don't know what fading and Doppler are going to look like over a 100–200 kHz bandwidth NLOS (non-line of sight)."

Photo A. The 6-meter antenna (left) is a monster!

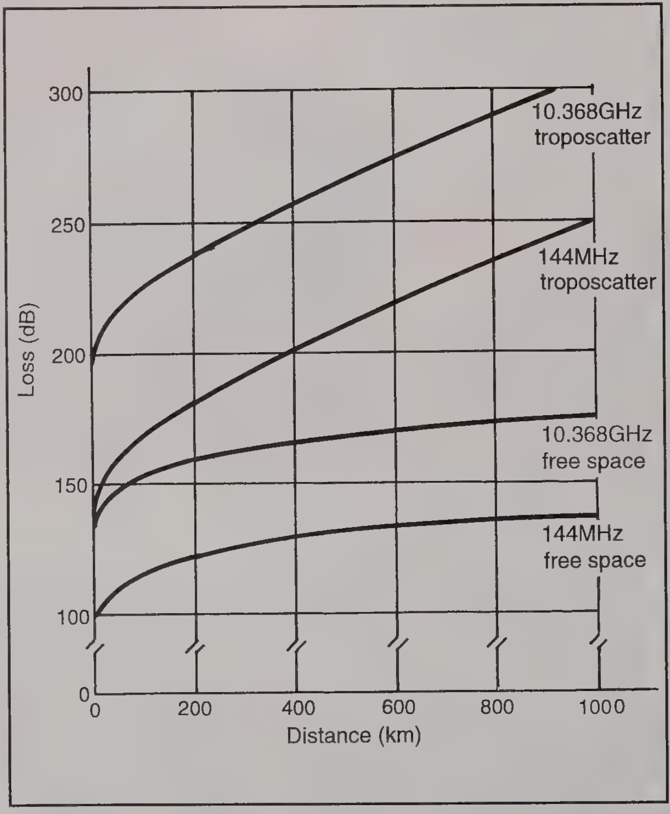

Figure 1. Troposcatter loss.

Photo B. Close-up of the 6-meter antenna.

its neighbors. This is a good fit for HSMM EmComm networks, which are created on an ad-hoc basis, and would allow for dynamic routing configuration as new nodes are brought online, or as some become unavailable.

Opportunities and Challenges

As an amateur radio operator operating under FCC Part 97, we have the benefit of experimenting with different RF technologies and being able to utilize higher power devices than folks deploying devices that adhere to FCC Part 15 regulations. What this means to us is that we can choose from a wide variety of radio spectrum (50 MHz, 900 MHz, 1.2 GHz, 2.4 GHz, and 5.8 GHz, etc.) and deploy those devices with amplifiers or high-gain antennas and create long-distance network links that cannot be achieved under Part 15.

Conversely, operating under Part 97 does offer some challenges, such as the use of encryption technologies. Currently, there is an approved process to utilize the basic encryption found in most WiFi access points; it is called WEP (Wired Equivalent Privacy). The downside to WEP is that with very little processing power the encryption can be decrypted. The HSMM Working Group is continuously working with the ARRL Chief Technology Officer (CTO), Paul Renaldo, W4RI, to find solutions to the encryption problem.

The Current State of openHSMM-ap

By the time you read this article, openHSMM-ap wireless access point should be available for download as an Alpha release. Running openHSMM-ap will require the use of a Soekris 4521 single-board computer and a WiFi card. The Soekris is a 486-equivalent computer with no moving parts. The lack of moving parts makes it an ideal candidate for enclosure in a weatherproof box to mount on the side of a tower.

The Future State of openHSMM-ap

There will be new versions of openHSMM-ap released throughout the year. They will include other features that will be helpful in creating true wireless networks. Some of these are a packet filtered firewall and a mechanism to limit bandwidth based on the type of service, which is commonly referred to as Quality of Service (QoS).

If you are interested in wireless networking, especially in the WiFi-type devices, you are encouraged to review the project web page (http://www. openhsmm.org) for up-to-date information. This may be just the type of device you want to include in your ARES/ RACES trailer or personal go-kit.

Deployment

In our local county, we have already identified and received permission to deploy these devices at four locations within the county. Neighboring counties have heard about our wireless networking project and are ready to become part of the local Hinternet. As it stands now, by the end of the year we expect to be connected to three surrounding counties and have a network that is capable of moving information out of an affected area in a timely fashion.

References

ARRL HSMM information: <http:// www.arrl.org/hsmm>
openHSMM: <http://www.openhsmm. org>
Soekris: <http://www.soekris.com>
Gwinnett ARES: <http://www.gwinnettares.org>

By Chuck Houghton,* WB6IGP

Above and Beyond, 1296 MHz and Up

Test Equipment for Power Measurements

Testing power at microwave frequencies can be somewhat perplexing if you don't have some basic tools. Some of the tools we will describe here might seem somewhat strange to those who are on the microwave frequencies. An example is the Bird Corporation Thruline wattmeters, and particularly the Bird 43 series of wattmeters.

Most amateurs who use Bird wattmeters assume they are good in frequency and power to about 450 MHz. Well, that's not true. They are capable of higher frequency operation and top out at 2304 MHz. I happen to have a selection of slugs that are rated at 5 watts for the Bird 43 meter. The slug for 400 to 1000 MHz performs fairly well at 1296 MHz and can be used at 1296 MHz with good results. You can obtain slugs that cover 1296 and 2304 MHz with better results.

A better method, however, can be brought into play. That is an AC-powered meter. The answer here is to use a low-cost microwave power meter from Hewlett Packard, such as the HP-432 power meter. To measure power above the +10 dB maximum all you need is an external attenuator to limit expected power to no more than +10 dBm. The HP 432A microwave power meter requires a connection cable between the thermistor power detection head and the meter itself. The power head is capable of a maximum power input to the meter of +10 dBm. If you exceed this limit, expect it to blow the thermistor internal to the power-meter head. Once gone or over-stressed with excess power, repair is possible if the thermistor is way out of balance. However, if it is open on one thermistor, it's gone forever and it's toast.

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I like the 432 power meter because it's inexpensive, and the 478A power head does have a few chances of repair if it is over-stressed. Open heads still have a good temperature thermistor and can be used in combination with a single older thermistor head to achieve an operational condition. It's tricky but it can be done.

I over-stressed a good 478A power-meter head measuring power with what I thought was a 30-dB pad that should have protected the thermistor. When I applied RF in the range of 5 watts, it pegged the power meter. I shut down the RF source of power as soon as possible and checked things out. I found out that the Bird 30-dB pad I was using was actually model xxx3C. I got bitten by the 3C part number; it was not "30" as I had thought. You have to check things out to be sure it is a 3-dB pad, not a 30-dB attenuator!

The power meter would no longer balance and was given the repair technique. I rebalanced the power head so it was again operational. Check your attenuators with an ohmmeter to see what is going on. Table 1 lists a few examples of resistance values measured on a few pads in my high-wattage-pad tool box. You can use it as a guide.

See what you have in your collection of attenuators. Many of them function over the frequency of DC to 12.4 GHz using "N" connectors, some very small ones operate from DC to 18 GHz with SMA connectors, and some function on spot frequency. Both the "N" and the "SMA" connector types can function with 2 watts of power for a short duration. The "N" types function for a longer duration. The frequency of operation is a few MHz to 12 GHz on many attenuators. Some are frequency specific. The higher wattage types with heat sinks might be limited to 4 to 5 GHz. Exact values of dB loss and frequency of operation are usually printed on the device. If you need a 10-GHz attenuator, check what you have with a signal generator, if you have one. If the price is good enough, regardless of frequency of operation, pick up the attenuator as an item to use for trade or for your work-bench parts-box collection.

Take a look at the accompanying photo of my work-bench junk box. There are diode detectors, both positive and negative devices for sweep generator use, and general test devices. At the bottom left are miniature directional couplers that

Manufacturer	Model	Frequency	Loss	A into Ground	B into Ground	C into Out
Narda	765–20	4 GHz	20 dB	52 ohms	52 ohms	50 ohms
Bird	XXX-3C	—	3 dB	152 ohms	152 ohms	18 ohms
Narda	3NM	DC–12.4 GHz	—	50W term	NC	50 ohms
Weinsch	—	DC–8 GHz	30 dB	50 ohms	50 ohms	91 ohms
Narda	768-30	DC–11 GHz	30dB	50 ohms	51 ohms	93 ohms
Narda	768-20	DC–11 GHz	20 dB	62 ohms	62 ohms	52 ohms
Narda	766-3C ?	—	30 dB	144 ohms	162 ohms	108 ohms
Narda	766-6	DC–4 GHz	6 dB	87 ohms	90 ohms	35 ohms
Micro Lab	AB20N	—	20 dB	52 ohms	52 ohms	83 ohms
Micro Lab	AD-10	—	10 dB	64 ohms	64 ohms	51 ohms
HP	—	DC–12.4 GHz	30 dB	50 ohms	51 ohms	51 ohms
HP	—	DC–12.4 GHz	20 dB	56 ohms	56 ohms	89 ohms
HP	—	DC–12.4 GHz	10 dB	63 ohms	63 ohms	42 ohms

Table 1. Examples of various value attenuators in my junk box

also can be tested with a VOM to see if they are alive. Check the through path and the 50-ohm termination, for example. Believe it or not, I have found terminations that were blown, probably from excess power application. The simple VOM can give you great confidence when you attempt to pick up equipment such as attenuators, diode detectors, and directional couplers at swap meets. Of course, further testing on your work bench is needed before you actually use the device so that you will not replicate my mistake regarding the "3C" pad.

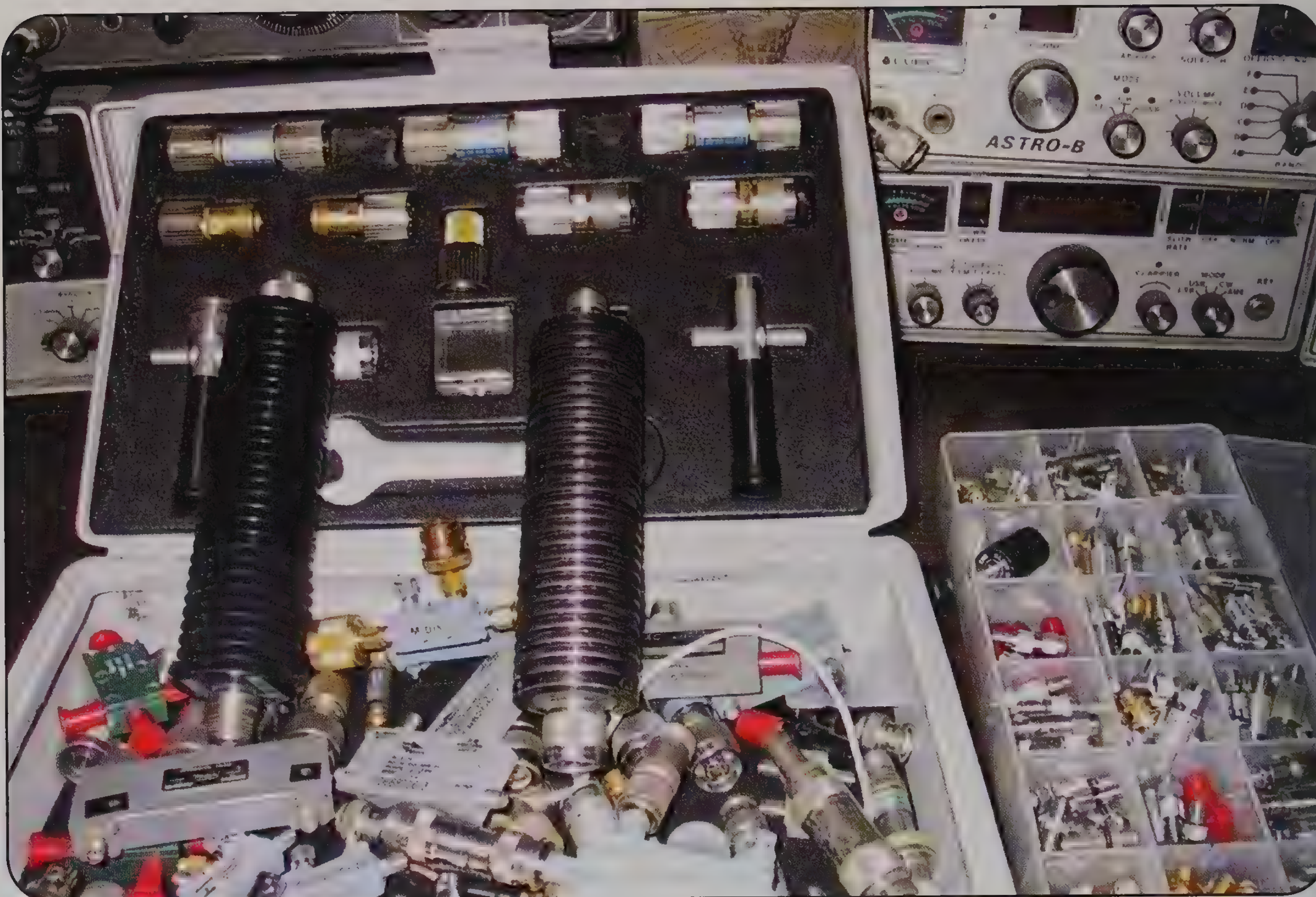
Check out all power meters that you find a swapmeets, because some may be a good deal, if only for parts. Who knows? You might get lucky and find a working 436A digital power meter for an unbelievable low price of $25! Checking out the HP 432 and 431 power meters, you will find that the 432 is an updated version of the 431 model, and usually one can be picked up for $25 or less. The cables to connect the meter to the thermistor detector head can be obtained for $20 to $35, and the 478A power head can be obtained for about the same price at swap meets or on eBay. All cables and power heads are interchangeable with the 431 and the 432 meters. I have a pair of 432 meters on the bench and love them. If you can, hold out for a 432 meter, as it's a great update over the 431 and is better in operation, drifts less, and is still low in cost.

To do a quick manual test of the 478A power-meter heads use a VOM. This will allow you to sort out defective power-meter heads on the spot at swap meets. Measure pins #1 and #3 to ground. They should be nearly the same resistance value, say 3K ohms. If the values are out of balance, the power meter (432A) will not balance its internal meter circuitry. Power heads way out of balance can be brought back to life by adding a very-small-value internal resistor to bring the meter back into balance. Send me an e-mail or drop your phone number in the mail to me and I will help you with repair techniques should you need it. Let's hope you don't need repairs, though!

Another great find is power attenuators, be they SMA miniatures or attenuators with heat sinks attached. These are usually fitted with type "N" connectors for the heat-sinked variety (see photo). The two big black attenuators in the photo are rated at 40 watts to 11 GHz.

If there are any specifications marked on the attenuator, pay attention to frequency of operation or possible power rating—e.g., 20 watts or loss value in dB. Here is where the VOM again comes into play. Test the attenuators with your ohmmeter to see what is alive. Most attenuators on the market are constructed with the "T" design; that's two resistors in series (in and out) and one from the center tap of the two series resistors internal to ground. Coax connectors get dirty, and don't let that taint your determination of the connector as good or bad. Give questionable center-connector pins a cleaning and then try the VOM test again. On "N" connectors they tend to become slightly dirty from general use. If the connector is gold plated, chances are it will be clean.

A set of pads and a good 432 power meter will allow you to make very accurate power-meter tests from a MHz to



Pads, including high-wattage versions (the large black pads). At the far right is a box of 1-dB step value SMA connectors.

12.4 GHz with confidence. To measure power at all microwave frequencies up to and including 12.4 GHz, again the best low-cost power meter is the HP 432. The frequency range can be stretched a bit with good calibration. Power-wise, in operation maximum input power is limited to +10 dB.

Now to measure a 10-watt TWT amplifier operating at 10 GHz. How do you do it? What you need is a 30-dB attenuator to reduce the 10 watts of expected power (40 dB). Connecting the attenuator output to the 432 power meter, you will read +10. This is true as long as the power amp or TWT for 10 GHz is putting out 40 dB of power. The power meter by itself is limited to +10 dB and extended to +40 dB with the 30-dB pad attenuator. To work in this manner is quite normal, as long as the attenuator used is rated to handle the 10 watts of power driving the 30-dB attenuator being tested. A 40-dB attenuator is a better choice to protect the thermistor head from excess power.

Another power meter is the Wavetek 1018B. It has an attached power-meter cable and head together with the instrument. On the expensive side, start off with the HP Digital 436 meter, which costs $100 to $150 for the meter, $75 to $50 for the meter cable, and $100 to $200 each for the power meter detector heads.

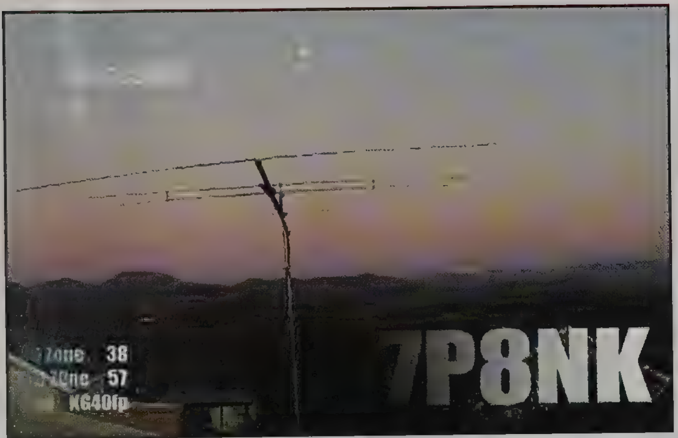
Also be on the lookout is attenuators, especially ones in the 10, 20, and 30-dB range, as this will give you a remarkable range of combinations of loss use, for example, use the 30-dB pad and the 10-dB pads together. Screw the pads together and you have a 40-dB attenuator. Using this combination with the power meter, you now have 10 watts indicating at 0 dB on the power meter a safety margin of 10 dB. I have measured a bunch of old attenuators in my junk box. Doing this gives you an idea of what to expect from your measurements of swap meet pads. There are a few bad pads in the examples in figure 1. I pick up even unknown ones without testing them *if the price is right.*

The pads in figure 1 are not actually bad, but some are over 10% of actual limits/pad value. For instance, I was checking my 10-watt TWT amplifier and only got +37 dB (5 watts of power). After further checking things out, I found a bad coaxial adapter from SMA to the type "N" connector. It looked good and was short free, but it was becoming hot with short applications of power. I replaced it with a name-brand adapter and got a full 40.4 dB of output power.

You never know when the snake will bite in this microwave world. Shown in the photo on top of the big white box is my collection of APC-7 pads. They act as my standards. The box in the bottom center contains the collection of everything else, with the high-wattage pads being the big black pads with heat-sink disks. The smaller box to the right is a collection of SMA pads in 1-dB increments.

This is material collected over many years. My latest find is a Narda 368BNM high-power termination good from 7 to 18 GHz at 175 watts. It is 12 inches long and 1 1/2 inches square and looks more like an old-time rectifier. Now all I need is a higher power 10-GHz transmitter to put the pad to use.

73, Chuck, WB6IGP



A quiet location with excellent ground gain, as proven by 7P8NK in August 2004. (Photo courtesy of VA7DX)

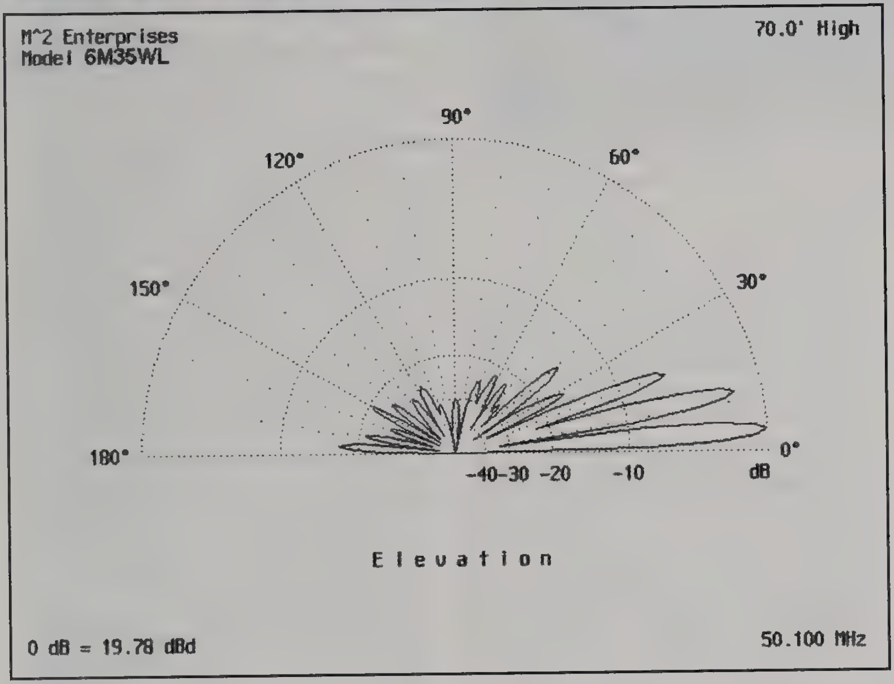


Figure 1. Vertical (H plane) plot of a single Yagi at W7GJ. (Courtesy of KØGU)

If you are planning to limit your EME operation only to the horizon, you also will want to make every effort to locate the station in as favorable a location as possible for the best possible ground gain. Usually, this means finding a clear, flat area, free of "ground clutter" (hills, boulders, or man-made objects such as houses, cars, etc., that can deflect ground-reflected signals away from your antenna). The best terrain for ground gain is salt water, although fresh water (such as a large lake or marsh area) or flat open ground also has been shown to work incredibly well.

When aimed on the horizon, the vertical pattern of a single Yagi antenna becomes a series of sharp, high-gain lobes and deep nulls due to ground reflections. For most small stations, one of the most critical elements in the equation for making an EME contact on 6 meters involves taking advantage of this extra "ground gain." Indeed, with a good, flat clear area in front of an antenna (unobstructed by a roof, HF antenna below the 6-meter beam, etc.), the ground gain of an antenna leveled on the horizon often makes a well located single Yagi perform like an array of two or four Yagis—at least when the moon happens to move in front of one of these lobes. The shape and elevation of these ground-gain lobes depends on the gain of the antenna and its height above ground. Generally speaking, ground-gain lobes are broader with lower gain antennas and lower height, although the lobes from such antennas also are higher in elevation and comparatively weaker.

For a single Yagi antenna at a typical "DXpedition height" (around 20 feet above ground), there is usually a good second ground-gain lobe up around 15-degrees elevation. The quality of the higher ground-gain lobes will depend more on the condition of the terrain in the near vicinity of the antenna in the direction toward the moon, and that is one reason this lobe often seems to be more effective than the "main ground gain lobe." It is much easier to have some control over the terrain a few hundred feet in front of the antenna compared to the landscape many thousands of feet away! Therefore, if you have the chance to set up by a lake or sea, it is definitely advantageous to be as close as possible to the water.

Of course, if you have the good fortune to be able to overlook a large lake or sea so that your most distant horizon is water, you will certainly also have a negative horizon, just from the curvature of the Earth. In such a case, you will find there is a "bonus ground-gain lobe" located around zero degrees elevation. Be sure to use this extra ground-gain lobe to advantage, and by all means plan to operate when the moon is down as far as negative 2 degrees! Just as important as locating your own station to maximize your own ground gain, it is important to look at the times when other stations will have ground gain to coincide with yours. This is especially important for smaller stations and/or stations limited to the horizon (either because they have no elevation, or because they have only very limited common moon window with you). The first assumption often is that there must be very little chance of being able to work another small horizon-only station. However, upon closer examination, one often can find a number of potential common moon windows when both single Yagi stations will have ground gain! Remember that you probably will have first and second lobes on both moonrise and moonset (perhaps plus an additional "zero degree" lobe due to a negative horizon), each of which provides an opportunity to match up with one or more similar lobes at the other station.

As you explore possible contacts, remember that the moon changes in declination every day, so new common moon windows are opened up with different horizon-only stations each day. As you plan your trip, you may also want to look at the times of day for your moonrises and moonsets. For example, if you are going out during a time of year prone to Es, F2 or TEP, you will want to pick dates affording windows in directions and at times of

6M7JHV Yagi during the J68AS DXpedition, June 2005. (Photo courtesy of W8QID/J68ID)

day least likely to be interfered with by these ionospheric propagation modes.

Generally speaking, any disruption of the geomagnetic field/ionosphere will have an impact on 6-meter signals. Even if the MUF is not high enough to produce effective ionospheric propagation at 50 MHz, the chances are quite good that signals can be deflected off their direct course toward the moon and back to you on Earth. Thus, ideally, one would avoid periods of expected cyclical disturbances (such as recurring 28-day coronal holes). However, the exact timing of these types of solar events often are not known with the same accuracy months in advance, the same way reliable Es, F2, and TEP seasons can be predicted.

In addition to the above-mentioned ionospheric considerations, there are two additional factors which can play a large role in the success of a 6-meter EME operation. Luckily, these are related to the moon's orbit and are very predictable. The first is distance to the moon, and the second is the sky temperature (noise) of space behind the moon.

The moon orbits the Earth once every month, and as it does so, it appears to move up and down in the sky. The moon therefore appears to pass through various spots on the celestial sphere, some of which are quiet and others that are extremely noisy down at 50 MHz. Of course, you generally also want to avoid days of the month for "new moon," since the noisy sun will be very close to the moon then. When the moon moves in front of a noisy place in the sky, trying to copy a weak EME signal is just as difficult as trying to hear someone whispering to you from across the room during a noisy party.

In addition, the moon moves closer and farther away from Earth over the course of its orbit each month. This change in distance alone causes a change in signal strength of about 2 dB. The combination of these two factors is commonly referred to as signal "degradation." Degradation is typically expressed as an index in dB, as compared to the ideal situation in which the moon would be at perigee (closest to the Earth) at the same time as the sky behind it is quietest. One would definitely want to plan a 6-meter EME operation during a time of month which affords the least amount of this degradation. These degradation figures (shown in real time on the JT65 operating screen) are also available in several of the popular moon-tracking computer programs available for use in planning purposes. One such free program that is still used by many EME operators is available at: <http://www.bigskyspaces.com/w7gj/tracker.htm>.

Unfortunately, the minimum degradation down at 50 MHz may not be much lower than a couple of dB, because perigee may not happen at the same time as the moon is in a quiet part of the sky. These two conditions move slowly in and out of sync over a period of years. Typically, the 6-meter degradation fluctuates between one or two dB and over 10 dB over the course of a month. If you have been keeping tally, you will notice that there are many factors that can reduce the already very marginal signal strengths on 6-meter EME! Obviously, when signals are just at the threshold of being detectable under the best of conditions, even just a dB or two makes a very significant difference! This may all begin to sound like an impossible game to win. However, with careful planning, the chances for success can be greatly enhanced.

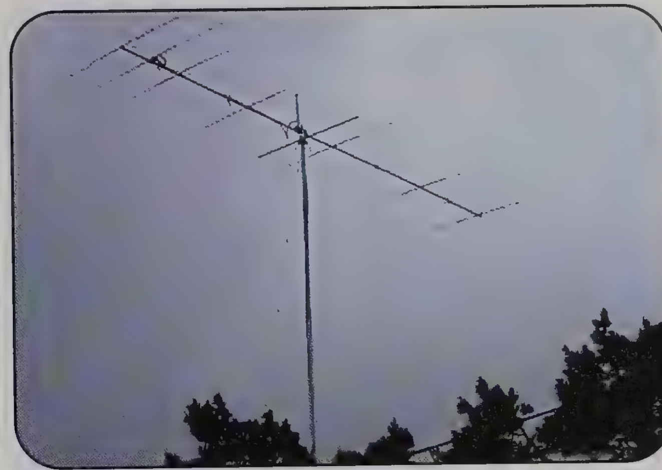
Equipment

Perhaps one of the most fundamential elements of a 6-meter EME station is a computer with an interface to connect it to the radio, thereby providing digital capability. An equally important requirement to operate in JT65A mode is to ensure some way to maintain accurate timing of the internal computer clock. The reliability of internal clocks in most computers—especially laptops—is usually quite poor. Ideally, one would like to be able to maintain half-second accuracy at least over the course of an hour-long schedule. If internet access is available, there are very popular programs (such as Dimension 4, Tardis, DXTIME, or Atomic Clock Sync) that can be used to automatically reset the computer clock at a selectable interval (such as every 5 minutes).

If there is no internet available, the most common way to keep the computer clock accurate is to use a GPS unit plugged into the computer running a program such as NMEATime. In the event that neither a GPS unit nor internet is available, the computer clock can always be set fairly closely by ear using WWV, and fine-tuned by adjusting the DSEC control on the JT65A screen until the displayed time closely matches that transmitted by WWV. (Such manual timing would have to be checked regularly, though!) This last method was the resourceful technique utilized by operator N9AB to complete the successful contact from J68AS for W7GJ's 100th country on 6 meters!

Another important piece of equipment is an amplifier. Outstanding results have been achieved by stations using the ACOM 1000 amplifier (kw on HF plus 6 meters) on 6-meter EME DXpeditions, but other types of amplifiers with at least 400 watts output can also be quite suc-

Addition of fans to reduce blower back pressure on W7GJ's amplifiers.



Seven-element Yagi at LA8AV/OHØJFB June 2004. (Photo courtesy of OHØJFB)

cessful. Note that even a 400-watt amplifier has 6 dB gain compared to a 100-watt transceiver. That 6 dB makes a huge difference when signals are just barely discernable, as they usually are on 6-meter EME!

It also is very important to make sure your amplifier can withstand the roughly 48-second full-duty transmit periods of JT65 mode. Usually, the addition of an extra blower or fan to increase the air flow will permit full power operation for this amount of time. Here at my station, I use a pair of high-volume fans to suck the air out of the plate compartment on my amplifiers. This reduces the back pressure on the blower and greatly increases air flow through the tube. With this simple addition, the exhaust only becomes warm—not hot—by the end of the full-duty JT65 transmit sequence.

Another very helpful accessory is a preamplifier for the receiver, although many people have completed 6-meter EME contacts without an external preamp. With most commercial transceivers one will definitely notice the improved noise figure of an external low-noise preamplifier—especially if operating during an optimum time of month (low degradation factor) from a quiet location. As long as there is low feedline loss (less than 1 dB), the benefit from such a preamp will be just as effective if it is installed right in front of the receiver, and that is they way they are used at most 6-meter EME home stations.

A very popular preamp among 6-meter EME stations worldwide is the CA50T, which features a PHEMT device for high dynamic range as well as very low noise figure. It is available through the manufacturer, LNA Technologies: <http://www.lnatechnology.com/lnatech_015.htm>. LNA also has a new RFCA50T model that is RF switched and can be installed directly between the amplifier and a transceiver.

Regardless of the type of antenna used for a DXpedition, it is very important to use good-quality feedline. The loss in the feedline will be very critical on both receive and transmit, and one of the advantages offered by a DXpedition operation often is the ability to set close to the antenna, so only a very short piece of coaxial feedline is required. The availability of low-loss coax such as LMR600 has been a tremendous asset in optimizing 6-meter EME stations: <http://www.timesmicrowave.com/content/pdf/lmr/28-31.pdf>.

Various types of antennas have been used successfully on 6-meter EME operations. As already discussed, the performance of a small antenna can be greatly enhanced through the use of ground gain. Most successful DXpeditions have used a single, good computer-optimized 6- or 7-element beam. You can view some such antennas in the article, with more examples at the following site: <http://www.bigskyspaces.com/w7gj/6mEMEstns.htm>.

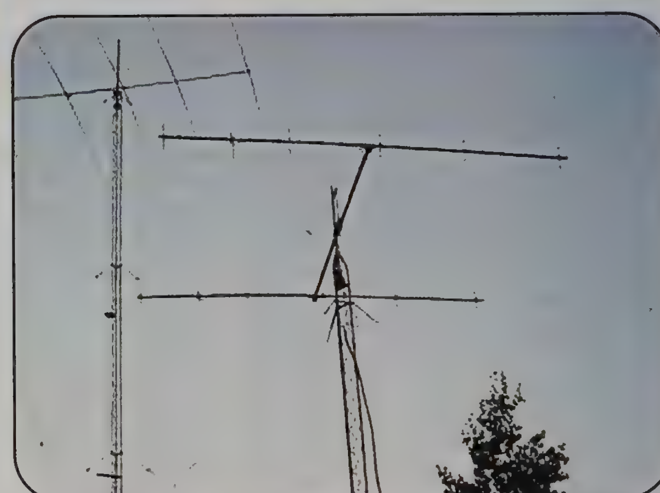
There are several good reasons for using the largest possible single Yagi. If the antenna is going to be aimed on the horizon, a single Yagi will generate multiple good ground-gain lobes, providing more opportunities to complete contacts. In addition, the second ground-gain lobe generated by a single Yagi is often more effective than the lower "main" lobe, simply because it is aiming higher, through less atmosphere/ionosphere, and is less subject to tropo ducting and/or interference from ionospheric factors. Another feature in favor of a larger single Yagi mounted as high as possible is that it will be higher and have a lower main-lobe angle of radiation, compared, for example, to a pair of smaller Yagis stacked vertically. In some cases where moon windows are very limited, it may be desirable to try to maximize the signal as low to the horizon as possible.

Of course, it also is mechanically much more secure for a portable operation to erect and guy a single Yagi as opposed to a vertical stack. If the object is to generate the most gain, a large single Yagi aimed at the horizon is the easiest way to do it!

Mast bracing and antenna rotating is most easily accomplished with a single yagi. If the azimuth and readout are manual, you can bury the mast in the ground (resting upon a solid object such as a board or concrete block), with a protractor around the mast. An indicator such as a bent paper clip taped to the mast is a very accurate and simple indication of direction.

Close-up view of the FT5XO 6-meter antenna (M^2 6M7NAN "Trip Yagi"), March 2005. (Photo courtesy of W7EW)

FP/N6RA 6-meter antenna (M^2 6M7NAN "Trip Yagi"), June 2005. (Photo courtesy of N6RA)



Six-meter EME array of two vertically polarized side-by-side Yagis. (Photo courtesy of NL7Z)

Mast bracing and antenna rotating is also most easily accomplished with a single Yagi. If the azimuth and readout are manual, a very effective method I have used on DXpeditions is to bury the mast in the ground (resting upon a solid object such as a board or concrete block), with a protractor around the mast. An indicator such as a bent paper clip taped to the mast is a very accurate and simple indication of direction.

The accompanying photos of M^2 6M7NAN "trip Yagi" installations show how the mast can be guyed effectively to withstand even high winds. Notice how the antenna at FT5XO is held at the desired azimuth by the two lines that are connected to the rear of the antenna. These lines can be either tied to fixed objects or heavy moveable objects such as concrete blocks (which can be easily moved around to change the aiming of the antenna).

The advantages of a single Yagi having been said, there also are some very good reasons to consider a pair of smaller Yagis mounted side by side. Even though vertically polarized Yagis will sacrifice a few dB ground gain when aimed on the horizon, they can be mounted and elevated quite simply to track the moon. Also, because of the mechanical arrangement, it is easy to aim the array as high as desired—even directly overhead if necessary!

If a pair of good Yagis is used, the free-space gain (when the antenna is aimed up off the horizon) can almost be as much as the very brief peak in ground gain generated by a horizon-only antenna. In addition, as more and larger 6-meter EME stations come on the air, portable operations utilizing antennas with elevation will make the best use of the available moon time.

An example of how a single long-boom 7-element Yagi with elevation could be used to expand available moon windows was illustrated by JA1RJU during his very successful May 2005 operation from KHØ. Although the elevation was limited to about 45-degrees elevation, the moon time was substantially increased. The elevation was manual, with very simple, easily transportable indicators, as shown in the photographs by JA1RJU.

One final note about DXpedition equipment concerns filters. To ensure that the portable operation does not interfere with local TV or other communication services, it is advisable to include a good low-pass filter on the transmitter. In addition, if HF amateur transmitters are being operated nearby at the same time as 6-meter EME activities are planned, it will be very important to make sure they also are equipped with low-pass filters and good grounds. In addition, it can be very helpful to have a supply of ferrite beads to clip over audio leads going into and

Seven-element long-boom Yagi at KHØ/KH2K. (Photo courtesy of JA1RJU)

Elevation indicator at KHØ/KH2K. (Photo courtesy of JA1RJU)

Elevation mount at KHØ/KH2K. (Photo courtesy of JA1RJU)

out of the 6-meter radio and computer, to make sure that HF RFI does not corrupt the audio lines of the EME receiver.

Operating Options

There are various strategies that can be employed by an EME DXpedition station. Some of the same considerations that have been used in CW operations also apply to JT65 mode operation. As with CW operation, it is sometimes helpful to consider split-frequency operation (if QRM is anticipated), and it also helps to have the callers on JT65A spread out a little bit in frequency. Schedules can be set up on one frequency, with random calls always welcomed on another frequency (or, preferably, a small range of frequencies). As long all the frequencies are not too far apart (no more than 1 kHz), they can be viewed simultaneously on Spectran, and the DX station can determine whether to continue to call the scheduled station or to reply to a random caller.

Since the familiar CW pile-up type of operation does not work very effectively with JT65 mode (which does not tolerate QRM well), setting up separate schedules is often preferred. The biggest problem with this approach is that it ties up large quantities of valuable moon time (which is especially limited if the DXpedition has a horizon-only antenna). On the other hand, random CQs will very likely create callers, but often not at the same time that the DXpedition can copy them.

The most productive technique demonstrated so far is this: Home stations who hear a CQ let the DXpedition station know they are being copied, so they can run a quick schedule. In this way, the DX station can sequentially run skeds with stations copying him. This is quite easy if both stations have access to the internet, but internet access is frequently not available in remote locations.

For remote DX stations with which there is no internet contact, it would seem that the only options are pre-arranged schedules or random contacts from CQs. Based on results from this year's 6-meter EME DXpeditions, and previous experience with 2-meter EME DXpeditions, it generally seems that calling CQ is usually more fruitful in creating successful contacts—at least as far as the DXpedition station is concerned.

However, because both stations may not be able to have extended common moon windows to wait for a suitable situation when a CQ can successfully be answered in real-time two-way contact (if such a situation ever indeed arises), there is still a need to accommodate some aspect of scheduling with an individual station.

Although basic JT65 contact exchanges and procedures are based on traditional CW protocols, there are some very attractive new features possible with JT65 that can be utilized to make random DX operation more successful. These new methods have been tried to a limited extent so far, but with good success. Obviously, what would be very helpful is some indication from random callers that they are copying the DX station; otherwise, the DX station can waste much valuable time calling stations that cannot copy him. One way this currently could be done would be for the caller to send callsigns plus received dB signal-strength level. This could indicate that reception was taking place, and there would be a good chance for a quick contact. Table 1 is a possible scenario, shown in alternating transmit sequences.

There are a few comments warranted regarding this random contact. The first is that K6MYC accepted a couple of dB handicap by sending the signal-strength report when he called J68AS to show that he was copying. However, this may well prove to

DX Station Xmit Sequence	Home Station Xmit Sequence	Comments
CQ J68AS FK94	—	Calls CQ and sequentially decodes callers using the JT65A FREEZE filter with DECODE button.
—	J68AS K6MYC -27	Answers CQ with current signal strength, indicating how well he is copying.
K6MYC J68AS FK94 OOO	—	Sees that K6MYC copies so replies to him with standard reports.
—	RO	K6MYC replies with standard *shorthand* confirmation and reports, which are easily recognizable visually to DX on Spectran.
K6MYC J68AS RRR	—	DX acknowledges with final RRR, while still sending both calls so others will know whom he is working.
—	73	K6MYC lets DX know the contact is complete, with *shorthand* message also visible to DX on Spectran.
CQ J68AS FK94		DX goes back to sending CQ.

Table 1. The sequencing of a random J65 QSO.

be an effective trade-off if the DX station is copying well enough. After all, a contact only requires 3 minutes, if both stations are fortunate enough to have mutual propagation, so it is important for the DX station to identify stations who are copying him at the same time he is copying them.

The DX station also accepted a couple of dB handicap by sending RRR along with calls. This is very helpful, though, in the event the DX station had previously replied to another station with a signal report (such as may be the case if he is interrupting a schedule to make the random contact). Similarly, the DX station could continue to send RRR to K6MYC for an extended period of time (even if K6MYC faded away for awhile), and not worry that the message would be misinterpreted by any other stations. This ability for the DXpedition station to answer a random caller (or even call CQ), and then continue to pick up again in the middle of a contact with a scheduled station, provides great flexibility for the DXpedition station, and greatly enhances the chance of successful contacts for all the stations.

In the above example, K6MYC is able to reply using the standard contact information without callsigns because the DX station will know they are being sent to him. Furthermore, the DX station will know that they are being sent from K6MYC, because the FREEZE filter already has been set on him, and his signal (and its exact frequency) can be seen on Spectran. Visually decoding the RO and 73 messages on Spectran allows the DX station to focus on decoding other stations and preparing to reply to other callers and/or returning to his schedule.

The rule that seems to be suggested by this scenario is that (at least when there are multiple callers detected) the CQing station working random should probably always send complete calls along with OOO, RO, and RRR, while the callers can continue to use the standard shorthand messages by themselves. However, please note that this is possible only if neither station has a portable callsign. For example, if the DX station had been FP/N6RA (or the home station had been G8BCG/P), it would not have been possible in JT65 to send calls at the same time as RO and RRR. An example of a JT65A screen showing a contact where W1JJ answered a CQ by W7GJ using such a protocol is shown in figure 2.

In the example, you will note that the RO sequence received at 1237Z had a "?" after it. A FREEZE filter with a narrow TOL then was set up centered on the signal's SYNC frequency, and the sequence was decoded again. The fact that the "?" disappeared indicated it was a good transmission. The screen shot was taken as W7GJ was repying with final RRR to W1JJ, using callsigns in addition to the final RRR (so other callers would know to whom the RRR was being sent).

The other required element here is that stations calling on random in JT65A mode ideally would spread out with 200 Hz between them. This spacing ensures that

Figure 2. An example of a JT65A screen showing a contact where W1JJ answered a CQ by W7GJ.

they will not interfere with each other, and the DX station can easily separate them using 50 or even 100 Hz TOL settings with their FREEZE filter. An arrangement that would appear to work here is for the sked stations to call 200 Hz *down* in frequency, while all random callers reply *higher* in frequency, trying to space out at 200-Hz intervals. The DX station could then clearly identify the sked station (as the only trace with negative DF) and still be able to see the random callers. To provide an opportunity to practice selecting and alternately decoding stations answering a CQ by using the FREEZE filter, six files are provided while W7GJ was completing first with K7BV (who indicated he was copying, by sending a dB signal level when he called), and then with K1SG. These can be downloaded from: <http://bigskyspaces.com/w7gj/JT65Apracticefiles.zip>.

The problem remains, of course, that with horizon-only capability, the DX station has little time available to wait for the polarity to rotate in order to complete a contact where propagation is not mutual. He probably needs to give it a good 20-minute try before going off to call CQ or answer other random callers. He can always return to the sked station later if he sees him again. If the DX station has elevation, he is not nearly as limited by a few narrow ground-gain lobes, and has the luxury of more time to operate random. In such a case, it makes sense for the DX station to set up schedules with horizon-only stations and/or stations with limited common moon windows, but also to always watch for off-frequency random callers and to call CQ during any non-sked times.

As experienced JT65 users are well aware, the visual aspect of receiving EME signals is an equally critical element in efficiently operating the station. Often, it is seeing the presence of calling stations during a receive period that provides the operator the extra time to decide where to set his FREEZE filter to be ready for the decode at the end of the receive period, so he can set his next transmit period accordingly. Obviously, if he simply visually decodes the final RRR shorthand message from one station, he can quickly set up to decode another caller instead, thereby being able to decode and reply to the new station before the next transmit period begins. Similarly, if he sees absolutely no visual trace from the schedule station, but observes another strong station calling slightly higher in frequency, he safely focus on the random caller. Or, if he sees a trace on the schedule frequency, he can set up to first decode that caller, and try to complete with the sked station. Callsigns and messages are quickly selected automatically by simply double clicking on the caller's callsign. It is the combined use of the visual waterfall display, along with skilled selective sequential decoding of various signals, that will enable the DX station to send the most judicious information, and thereby maximize EME contacts. You will be able to practice recognizing the appearance of the shorthand messages, as well seeing the different callers, if you download the above practice files.

Conclusion

In conclusion, I can't over-stress the importance of effective planning and some actual pre-trip practice with the JT65A software and the particular equipment assembled for the DXpedition. With good planning and preparation, you can enjoy the results of "Ultra Long Path" contacts, even if the 6-meter band would otherwise appear "dead."

Whether you are planning a DXpedition for meteor scatter, VHF contesting, or HF, I hope you will think about adding 6-meter EME capability as something special to fill the time when the moon is beckoning. Here's wishing you a healthy amount of good luck in making some very special "Celestial Magic" on the 6-meter band! ■

load packaging, telecommand, recovery, flight prediction, balloon selection, and how to improve our techniques. In true ham fashion, there was much being done by trial and error. Murphy's Law was a frequent visitor to each launch.

One group near the Gulf of Mexico had put color TV and other nice electronics into a payload package that was not waterproof and could not float. The winds aloft carried this flight out over the Gulf, never to be seen again. They now launch much farther inland and pay much closer attention to the winds aloft! There are lots of stories about the bumps in the learning curve.

In order for us to share our stories and experiences, a conference dedicated to ham ballooning, the first National Balloon Symposium, was hosted in Denver by Edge of Space Sciences (EOSS) in August 1993, just two days after the recovery of our flight number two. Groups represented at this first conference included the host EOSS, Pacific Northwest Balloon Launch Team, Bill Brown (WB8ELK), Perryton High School "Reach for Space," Wichita Area Balloon Chasers, Space Science Over Kansas (SSOK), North Texas Balloon Project, Utah State University, and HABET (Iowa). The *EOSS Handbook* and *Symposium Proceedings* helped fill the information void and allowed many more individuals and groups to get into ballooning.

My guess is that probably over 600 ham missions have flown. For instance, Reach for Space number 20 was one of the six that flew on Saturday, April 16, 2005. Interest in flying balloons is on the rise. Ralph Wallio, WØRPK, is collecting records of the various balloon flights and posting them to a web page at <http://users.crosspaths.net/~wallio/>.

Photo D. Each part of the payload is controlled by one person, with the lines lying flat in each person's hands.

There is Always a Parachute

The parachute is made from rip-stop nylon, which costs about $5.00 a yard. The most visible colors are fluorescent pink, yellow, or orange, and a yard and a half makes two parachutes. Of course, you need two only if you lose the payload, since the parachutes are reusable! Cut six panels, using the pattern, and sew them together. Press each seam to the side and sew again, 1/4 inch from the seam, and trim off the excess.

The top of the parachute is open and hemmed, with crossed straps made of 1-inch strips of the nylon folded in half, then the sides folded into the middle and sewn. These are pinned in an X across the opening and securely sewn to opposite sides of the hole. Hem the bottom of the parachute, and attach grommets (metal eyes) through the hem at each seam (and halfway between, if you prefer). These are applied with a special pair of pliers (about $12.00) or a hammer and the little shaped rod that comes with the grommets.

Four feet of nylon string is tied through the grommets, double knotted, and then hot glue is put on the knots. One of the tips we got from other groups is to add a hoop at the bottom of the parachute strings to prevent tangling and loss of the payload if the parachute doesn't open. The end of each string is then tied to the hoop, double knotted, and hot glued. A swivel is attached to the center of the crossed strips at the top to separate the rotation of the balloon from the payload. Four lines go from the hoop through the eye of another swivel for the payload string below. A drawing of the finished product can be seen in figure 1.

Keep It Legal

We may not think about it, but there are regulations concerning what can be located in the air above us. For instance, did you realize there are regulations for the little rubber balloons that you see at car dealerships? I suspect the owners of the car lots are not aware of those regulations either.

Rules for blimps, kites, unmanned rockets, moored balloons, and unmanned free balloons are found in Part 101, subchapter F, Air Traffic and General Operating Rules, of Title 14 of the Code of Federal Regulations (this string of words is the official name for the regulations). There is some room for interpretation as to what is meant by "use a rope or other device for suspension of the payload that requires an impact force of more than 50 pounds to separate the suspended payload from the balloon." We had some students run a series of drop-weight tests on #18 stranded nylon string. They found the breaking point to be 11 pounds. We use up to four strings in parallel for the load-bearing lines that hold the payload to the parachute and the parachute to the balloon.

Some other groups interpret this to mean a cutting force and use a stronger string than we do. We know to melt the ends of the nylon string after we cut it, but learned the hard way that knots in the string can untie themselves. Here was another opportunity to learn a lesson.

Lesson 8: *Hot glue all knots.* Needless to say, knot failures are not any fun, especially when they untie themselves at some altitude!

In the regulations there is a blanket exemption for payloads under four pounds. If you meet certain size requirements, then the payload can be up to six pounds, and it is possible to string on several payload packages if everything is 12 pounds or under.

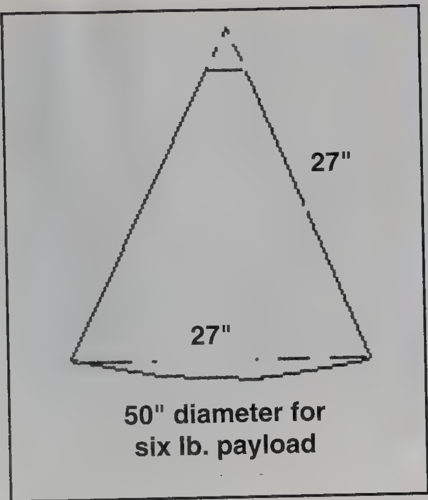


Figure 1. The finished product.

Photo E. Mike Helm, WC5Z, with his "little" direction-finding antenna.

More regulations: "No person may operate an unmanned free balloon in such a manner that impact of the balloon, or part thereof including its payload, with the surface creates a hazard to persons or property not associated with the operation. . . . Nor may you operate during the first 1,000 feet of ascent over a congested area of a city, town, or settlement or an open-air assembly of persons not associated with the operation." These regulations led us to yet another lesson. . . .

Lesson 9: *Move launches away from the school and town setting.*

Also, as the regulations say: "At least two methods, systems, devices, or combinations thereof that function independently of each other are employed to terminate the flight of the balloon envelope; and the balloon envelope is equipped with a radar reflective device." If you fly latex balloons, the natural bursting characteristic of the balloon counts as one of the cut-down devices. Rubber balloons are required to have two devices. Cut-down methods will be discussed in another section of this article.

A radar reflector is a simple addition. A friend connected with an oil field told me about a field experience in the late 1960s near Midland, Texas. Work was slow, so to entertain themselves, someone brought out a big party balloon. They filled it with some helium, tied a roll of aluminum foil to it, and let the foil unroll as the balloon took off. They were having a lot of fun until a couple of interceptor jets appeared overhead. They ended up agreeing with the Air Force officials that chasing jack rabbits would be a much better cure for their boredom, and they said they certainly would never do that again.

I assume this story confirms the usefulness of aluminum foil as a lightweight radar reflector. For several flights we laminated 12 to 15 feet of aluminum foil. Now we use the "space blankets" to make mechanically stronger reflectors. These rules can be found on the EOSS web page at <http://www.eoss.org>.

Payload Containers

Each group seems to have its own favorite payload container. On our flight number 20, we experimented with duct taping things to the outside of a payload container. As long as the batteries don't freeze (at –60° Celsius), it appears the electronics will function fine. We have many great photos from a Vivitar 35-mm digital camera that was included in the duct-tape experiment. The 2-meter beacon transmitter belonging to Michael Helm, WC5Z, provided a good signal until the center conductor of the antenna broke off at the circuit board. Michael describes his beacon and camera circuit in his article entitled "A Telemetry Beacon and Digital Camera Controller System for Experimental High-Altitude Balloon Flights," which appeared in the Fall 2005 issue of *CQ VHF*.

The taping of additions to the outside of the packages is not a recommend practice. We have used Styrofoam™ picnic coolers, Styrofoam™ minnow buckets, insulation board (for houses), foam core, aluminum boxes, cardboard boxes, and plastic food containers. A plastic food container is our favorite. Inside the container, a Styrofoam™ block is cut out so each item has its own space and is surrounded on all sides when the lid is put on.

Because switches can accidentally be turned on or off at the wrong time, we bring the power lines outside the box and use a polarized quick-disconnect power cable (#270-026). It is very easy to visually inspect for plugged or unplugged connection status.

In receiving signals from the balloon, we have experienced deep fading when using horizontal polarization, so now we use vertical dipoles made from hook-up wire. Ice picks are used to make the necessary holes, and after the wire is passed through, hot glue is used to seal the wire in place.

If we will need some warmth inside the container, we use chemical foot or hand warmers we obtain from a sporting-goods store. Right before lift off, someone crumples the warmer, puts it inside the container, closes the lid, and tapes it shut.

For power we use a surplus lithium battery rated 3 volts at 7.5 amp-hour. These batteries are available from S & G Electronics, Philadelphia, PA.

Each group has its own favorite container. In order to increase the ground range of the 2-meter signals, some are

experimenting with designs for the payload always landing top up, placing the 2-meter antenna up off the ground. Some are using nylon jackets to protect the outer surface of their packages. The packages range from the simple to complex, depending on the goals and talents of each team.

Cutdown Devices

There are times when a group may want to bring down its payload before the balloon bursts. This is typically done if the balloon is traveling to an undesired area, such as over a large body of water, into restricted airspace, or over a city. There are three kinds of devices: incendiary, heated nichrome wire, and a guillotine, using a razor blade. The most common is the nichrome wire used to melt nylon cord. Each is activated by a radio signal, sometimes independently of the rest of the payload, and sometimes as part of a set of commands. The device usually has its own power supply. Craig Brunson, N7TSZ, of the Reno (Kansas) County Amateur Radio Association, RCKARA, describes the group's device in these terms:

> We use ~3.5 inches of 30 AWG nichrome wire and heat it with either two each 2/3 A (6V) or three each 2/3 A (9V) lithium batteries. This is used to cut 215 lb., 550 lb., and 1000 lb. nylon cord. It will cut the cord in 3 to 5 seconds. The nichrome is wound around the cord with seven loops. This is the standard cutter that we use for NASA and NOAA. It is not affected by the cold and has been tested dozens of times to well over 100K ft.

The group's website has pictures from the Great Plains Super Launch 2004, as well as other information, and it is well organized. Go to: <http://www.rckara.org>. A very clear photo of the device used by Michael Gram, KD7LMO, of Arizona Near Space Research, is on the group's website at <http://www.kd7lmo.net/cutdown.html>, along with a short description. Wire may become brittle at the extremely low temperatures of near space, and the group recommends Teflon®-coated wire instead of common CAT-5 ethernet cable or telephone hookup wire. Recommendations and devices are the result of flights with failures. It is valuable to learn from other groups, rather than repeating the experience!

HOBO Data Logger

The HOBO data logger is a tiny, lightweight logger that receives input from sensors and stores it until it is downloaded upon recovery. Onset, the manufacturer, produces a line of sensors for recording temperature data, as well as a variety of other sensors. Paul Verhage, KD4STH, has published instructions for building your own light and temperature sensors in *Nuts and Volts,* a publication we highly recommend if you enjoy hands-on electronics. Paul gives lucid, detailed instructions for building components, and high school students can follow his directions independently. One of the benefits of our balloon flights is the enthusiasm for science and interest in the environment that students experience, especially when they themselves build some of the payload. The HOBO data logger is an excellent addition to a flight.

Photo F. It's out in this field somewhere...

Student Experiments

One of the goals of near-space research is to give students the opportunity to try some of their own experiments in conditions they would not have had otherwise. Our students at Perryton (Texas) High School have flown experiments investigating cosmic rays and devices to sample air pollution at different heights in the atmosphere. Ordinarily, the students involved are university students who may design their own circuits and test data collection devices, radio propagation, or control commands in writing their own programs.

Simple experiments that fit in a ping-pong ball are an exciting idea for younger students, and they have tested ideas such as the effect of conditions of near space on seed germination or bacteria viability. The research and design of simple experiments is a valuable exercise in problem solving. Publication of university experiments, especially with stamp controllers, may be found at <http://www.parallax.com/html_pages/downloads/apps/third_party_articles.asp>.

Paul Verhage, KD4STH, is compiling his articles in *Nuts & Volts* into an e-book published on the Parallax website at <http://www.parallax.com/html_pages/resources/custapps/app_nearspace.asp>, and he includes suggestions for student experiments.

While telemetry data can be sent down via radio frequencies, with our simple circuits only a very limited amount of data can come down. In his articles Paul brought to our attention data loggers. These tiny modules record lots of data. We chose a four-channel HOBO from Onset. The unit is very small, about the size of a matchbox, and weighs less than 1 ounce. Recording data every second, it will collect for 2 hours and 15 minutes, while recording in 60-second intervals it will collect for 5 days and 15 hours. With these devices it is easy to become buried in data!

APRS

One of our trackers, Joel Bennett, KK5XS, says, "The use of APRS (Automatic Position Reporting System) is somehow like cheating." Joel prefers the manual triangulation methods of tracking. Receiving the position reports from the balloon is fantastic until something causes the loss of data. We find it is a good idea to have our chasers equipped for both the APRS and manual techniques. A program called Balloon Track is available from EOSS, and it provides a prediction of the eventual touchdown spot, if the information entered into the program is accurate. Necessary information includes winds aloft, lift, ascent rate, payload weights, and balloon size and type. The winds aloft are available from the National Weather Service from its twice-daily releases; we download them from the University of Wyoming website at <http://weather.uwyo.edu/upperair/sounding.html>.

Photo G. The payload was recovered in less than half an hour from "splashdown"!

GPS units are available as engines, built into the antenna, or as complete hand-held units. Check on the Ralph Wallio, WØRPT, web pages for the units that will work above 60,000 feet. Many units are altitude limited. The hand-held Garmin Etrex and model GPS-35 (engine built into antenna module) have been flown successfully by many groups (see <http://users.crosspaths.net/~wallio/>). Also, Ralph's balloon links list 59 groups, so there may be a group near you. The records lists are very interesting reading as well.

Popular TNC units are the Tiny Track and Pocket Tracker from Byonics (http://www.byonics.com) and Scott Miller's Opentracker (http://n1vg.net/opentracker/). Scott offers group and education discounts. Balloonists use the 144.390-MHz national APRS frequency, and more are going to 144.340 to get away from the congestion of the national frequency.

Many groups I-gate their balloon's APRS information onto the internet. Many use a –11 on their call-signs. On <http://www.findu.com> watch for WBØDRL, KD4STH, K5IS, KE5BFH, WB8ELK, KD7LMO, W5ACM, KC7NAX, KEØVH, N4TXI, N9XTN, and W5SJZ. This is a partial listing. On any Saturday and Sunday you will find balloon tracks being displayed.

Into the Future

More groups will be flying. It would be interesting for weak-signal operators to have the use of linear translators as cross-band repeaters for SSB and CW signals. More experiments need to be done on the microwave frequencies. Much more work needs to be done to eliminate the electromagnetic interference (EMI) between the components within a payload package. In our own projects we would like to add an interface to translate sensor data into Morse Code.

We hope to see many more partnerships between balloon groups and students of all ages. The age of near-space exploration by private citizens has arrived!

Summary

We have had a steep learning curve, and it has been an exciting adventure. We began with the idea of designing balloon flights that were inexpensive, with a basic package of two beacons, transmitters, a camera, and simple packaging. We have come to appreciate the addition of more complex components such as digital cameras and BASIC stamps. No one warned us that balloon flights can be addictive, even if they are frustrating.

One of the most enjoyable aspects of the experience has been the cooperation between groups and individuals. Few people can master all the skills needed for a complex flight, and the contributions of fellow hams have been welcomed and appreciated. We have learned from each launch we have attended or done ourselves. And when you get down to it, it is just a lot of fun! ■

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Doerrie, Jerome. "Flight Number 9: Ballooning on a Budget," *CQ VHF,* Sept. 1996, pp. 32–37.

Doerrie, Jerome. "Reach for Space-Flight 9," *Central States VHF Society Proceedings, 1996,* pp. 137–141.

Photo 4. Joe, W5KTX, measures the resistance of the #6 ground wires attached to the copper-clad steel rod encased in the center of the 8" × 8" × 9' trench.

Site	Location of Conductor	Resistance (ohms)
Fort Stockton	Radio shack	0.27
	Tower Base	0.25
	Guy Anchor	45.0
	Meter loop butt plate	4.3
Sanderson	Radio Shack	0.17
	Rod in trench 8" deep	0.1 (0.04)*
	Tower Base	0.17
	Guy Anchor	743.†
	Solar-panel support rod	4.3
	Meter loop butt plate	590.

**The AEMC instrument accuracy is not defined for reading below 0.1 ohms.*
*†Average of 3.**

Table 1. Findings to date.

as at Sanderson, the continued absorption of ambient atmospheric condensate may be an adequate source of ionic activation of the bentonite.[6] Published measurements of resistivity of a typical soil vary from $>10^6$ ohm-cm for 0% moisture to $\sim 10^3$ for 30% moisture. We also must measure resistance in midwinter, when the earth's surface has cooled. Marked variation in resistivity occurs with temperature changes:

At 20°C resistivity is $>10^6$ ohm-cm; at 40°C (not uncommon in west Texas) soil resistivity *decreases* to $\sim 10^{1.5}$ ohm-cm. In our Texas desert, rain, excluding thundershowers, is often rare for months at a time Heat is predictable and it surprised one of us that the sun is on our side!

Geometry of the bentonite ground is relevant. The resistance to earth of a rod driven into homogeneous soil is characterized as a series of concentric buried spherical elements. A solution for resistance of a single rod is (after ref. 4):

$$R_0 = \frac{\rho}{2\pi\ell} \ln \frac{4\ell}{d}$$

where d = rod diameter in cm, ρ = earth resistivity in ohm-cm; ℓ = rod length in cm; and ln is the base of natural logarithms.

Note that length, as well as the logarithm of length, affect the resistance, with length predominating over diameter in its effect. However, it can be shown (ref. 4) that 92% of the resistance of a 10' × 1" rod is obtained within a 20-ft. radius cylinder.

Kostic, *et al* [3] compared periodic measurements of resistance for 1000 days. Their test setup consisted of zinc-coated steel strips laid in trenches 0.6m deep × 0.3m wide at the base, formed in a loop 5m × 5m. They show rather wild variations of resistance over time in the conventional buried-loop ground, whereas both bentonite suspension and powdered bentonite poured in the ground strap trench maintained a low nearly constant resistance through the observation period, which included Yugoslav winters. Of interest in west Texas was their comparison of the resistance of ground loops backfilled with waste drilling mud. Although resistances started out fairly identical for the first 200 days, there is divergence toward higher resistance in the mud, as compared with fresh bentonite.

Kostic, *et al* also evaluated the corrosiveness of bentonite. Based on measurement of corrosion velocity of the zinc-coated steel strips, they characterize bentonite as a *very inactive* corrosive material (0.005 mm/yr.). Drilling mud measured 0.05 mm/yr., and is characterized as an *inactive* corrosive material. They also conclude that bentonite powder can be "successfully used instead of bentonite suspension." This finding markedly decreases the expense and labor required to install a grounding system.

Jones[2] reports similar experiments conducted in upstate New York. They investigated the effects of bentonite used as backfill in hardpan silt, clay-cobbles-gravel, and mixed soil with a sandstone layer beneath. Driving rods into hardpan and the sandstone was nearly impossible. They broke drill bits in achieving usable holes to insert rods and backfill. No comparison measurements were possible with the hard pan, because driven rods bent over after going 1 foot into the soil. Hardpan resistivity was nearly constant over one year at 3,700 ohm-cm. For clay-cobbles, a 23% reduction in resistivity (2,060 to1,590 ohm-cm average over one year; for sand and silt over sandstone, 36% reduction of resistivity (4,260 to 2,710 ohm-m). The advantage was constant over the year of observation.

Jones shows that the advantage is a "direct result of increasing the effective surface area of the ground rod." Using the equation above, he showed that (for very non-conductive surrounding soil) increasing the effective diameter of the rod from 5/8 inch to 6 inches produces a 34% improvement, regardless of resistivity. These figures compare favorably with their experimental results, reported above. If, in solving the rod resistance equation, an assumption of negligible resistivity in surrounding soil is untrue, "bentonite's benefit will diminish…The greatest % reduction in rod resistance will be realized with resistivities over 10,000 ohm-cm."

Photo 5A. Direct clamp-on measurement of the ground conductor resistance near the radio shack. Unit reads less than 0.1 ohm, its limit of resolution.

Because we lacked the drill rigs available to Jones, we opted for the approach reported by Watts.[1] We were able to borrow a heavy-duty electrically powered rock hammer to make the shallow trench required. Watts's trenches were sometimes 24 inches deep—beyond our aerobic capacity! (Watts had a narrow bucket backhoe and often dug three trenches.) This was, by far, the most difficult part of the installation, with slurry mixing an equally muscular task. Both Kostic and Watts showed that one could just pour the powder in the trench. We expect to do this for the next project, but we will require some heavier backfill to keep the bentonite in place. They made a point of brazing their copper connections for a better bond. This, too, is an excellent suggestion!

Photo 5B. Direct clamp-on measurement of the utility pole ground-wire resistance—590 ohms.

For amateur radio operator purposes, there are several ways of making underground connections that provide molecular bonding. Exothermic techniques such as "Cadweld" [7] are well known. The Burndy HyTap[8] compression techniques do not require heating or exothermic processes, but use mechanical compression of up to 12 tons to provide near molecular bonding and are UL-listed for direct burial.

Conclusion

We tried a recently reported technique for acquiring adequate earth connections at rocky desert radio sites. By pouring bentonite slurry around our $^5/_8$-inch rod, we constructed an 8-inch thick cylinder whose exterior tightly adheres to the surrounding rock. If repeated resistance measurements demonstrate values one ohm or below, we shall use this inexpensive adjunct more widely.

Added Note . . .

Last spring lightning struck nearby. All of our AC circuit breakers were destroyed and all power-supply fuses blew out. However, none of the equipment, including two C-MOS UHF repeater controllers, suffered any detectable damage. We had the site back on the air within minutes of our arrival! ■

Notes

1. Watts, LB, 1980, Improved grounding system for mountain top radio sites. Personal communication.
2. Jones, WR, 1980, Bentonite rods assure ground rod installation in problem soils. IEEE Trans Pwr Apparatus and Systems. Vol. PAS-9(4) July/Aug 1343–6.
3. Kostic, MB; Radakovic, ZR; Radvanovic, NS; Tomasevic-Canovic; 1999, MR Improvement of electrical properties of grounding loops by bentonite and waste drilling mud IEE Proc.-Gener. Transm. Distrib. Vol. 146 (1) Jan 1-6.
4. Anon., Military Handbook: Grounding, bonding and shielding for electronic equipment and facilities. 1982 US Dept of Defense MIL-HDBK-419A. Available from DOD Stock Point; Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120. Also available at: <http://tscm.com/MIL-HDBK-419A.PDF>.
5. Chauvin-Arnoux, Inc. d.b.a. AEMC® Instruments; <www.aemc.com>.
6. Rudenberg, R.. cited in ref. iv above.
7. Erico International: <www.erico.com>.
8. Framatone Connectors, Burndy Electrical: <www.portal.fciconnect.com>.

The transverters with an integrated class-A brick would be drawing power when not transmitting. For now, this seemed to be an acceptable tradeoff.

Bells and Whistles

Having accomplished basic control, I decided to try out reading the frequency of my IF rig, a Yaesu FT-857D, adding the offset for the actual microwave band I was on and displaying this on the screen at the same time. I created a polling loop that reads the radio using standard CAT commands and displays the current frequency ($f = f_{IF} + f_{LO}$) on the display. This worked great, and it was reactive enough to be able to watch the display change rapidly as I tuned around on the band with the knob on the 857. Whenever the software is not processing any other commands, it is in a loop reading the radio and updating the frequency display.

It's really not a big problem to know what frequency you are on, since most of the time 144.100 coincides with 2304.100, 3456.100, etc., so no real mental gymnastics have to take place. There are times, however, when a transverter oscillator will not reliably start on the desired frequency, which necessitates setting the LO up off-channel. Since the control system is able to add any arbitrary LO offset, you can now look at the display and dial seeing the actual frequency you are on (let's forget drift for a moment!).

I also added a few features that seemed as if they might be of use during a contest. First, I added memory to remember the current frequency on the band in use. Whenever I switch off one band and went to another, I save the frequency in memory. When I switch back to the original band, the frequency is reset on the IF rig. This is great for situations where I work someone on a higher band and return to a liaison frequency, and then someone says, "Hey, I heard you up there. Can you go back and I can work you there, too?" It's just a button push away. This also eliminates some of the mental gymnastics associated with remembering on which bands the transverters are slightly off frequency. The Fluke 1780 and my Yaesu 857D are shown in photo 3.

Display Troubles

While the 1780A was a good solution on the bench, keeping a 110-volt display running mobile has its challenges.

First was the mounting challenge. The 1780A weighs 18 pounds and is 14" × 11" × 6". Mounting this in the truck where it is accessible has proven troublesome. At present, the only good solution seemed to be to place it on the dash in front of the passenger. This allows the logger to control the transmit band and the display is still readable by the driver. I used long strips of hook-and-loop fasteners to mount the display and have successfully driven the display over a number of rough Colorado mountain passes. The fasteners work well once the adhesive has had time to cure.

My second problem was keeping the display properly powered. Initially, I figured I would just use any 110-volt inverter I had on hand. I had a 700-watt Xantrex inverter handy, and I did some testing in the truck with this unit. All seemed fine until my first contest. The display went blank about 20 minutes into the contest. Upon examination, I found that the fuse had blown. Fortunately, I had brought a backup 1780A, and I quickly swapped out for this one (figuring that a real internal problem had blown the fuse). When the fuse on the second 1780A blew another 10 minutes into the contest, I began to suspect the inverter. I ended up switching to a backup inverter rated at only 250 watts that I had brought with me. This inverter has been in continuous use since that contest and has created no additional problems. Apparently, there is something about the Xantrex that was blowing fuses in the display.

Photo 4. Microphone sense and PTT control cable.

Later I added a TE Systems 350-watt 2-meter amplifier to my mobile configuration and found that I had RF entering the display, causing it to lock-up. The logic in the display, although somewhat shielded by the case of the unit, is still susceptible to a high RF environment. With my initial homebrew 4-element 2-meter antenna on the roof of the truck and the control electronics in the cab, the display relaibly would lose its mind when I keyed and talked on 2 meters with the amp on. I tried placing toroids on the AC line and the RS-232 line to the display with no improvement. For a recent trip, I swapped the antenna for a 2M7 from M^2 and moved the control electronics to the bed of the truck. The problem subsided. Nevertheless, as I add amplifiers on other bands, this problem is likely to reappear.

My long-term solution to these problems is to replace this with a custom control head or perhaps even a laptop. Having said that, I believe the 1780A makes a very good display for home station control. It's just not ideal for mobile use.

Expansion

Having been bitten by the microwave bug, and considering the success of my control system, I expanded to include all bands from 6 meters through 3456 MHz and 10 GHz. My IF radio handled three bands directly—6 meters, 2 meters, and 440 MHz—since they all were in the radio. My switching for these bands just controlled the antenna the radio was on. For bands with a transverter—namely 220, 902, 1.2, 2304, 3456, 5760 MHz, and 10 GHz—I used a six-position coax switch. This is actually seven transverters, but 220 is connected to the TIB directly, since my IF for 220 is 28 MHz. The relay position is directly controlled by I/O lines.

Photo 5. Steve, N5AC, operating the touch-screen control system.

With the number of transverters I had now, it seemed prudent to control the PTT directly. I had some concerns about using the PTT out of the transmitter, since it only goes active once the transmitter is already transmitting. If it took too long to key the transmit on the transverter, it might be damaged by keying into the IF output of the receiver. Instead of risking this, I built the small connector shown in photo 4 to take the key output to the transceiver and use this as an input to the BASIC stamp. I used one of the RJ-45 female-to-female connectors, split it open, and then split the PTT line and the ground out using a 3-pin stereo jack. By

Photo 6. Greg, WDØACD (left), and Steve, N5AC, at the 2005 NTMS/RMG 902 and Above contest.

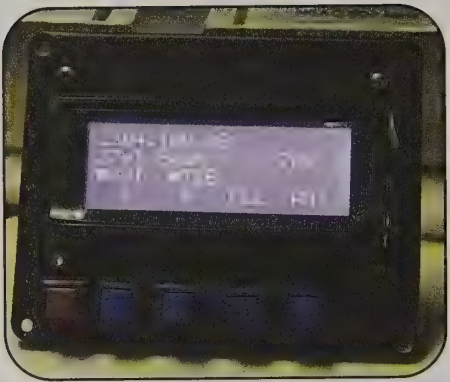


Photo 7. LCD control head.

doing this, I could watch the microphone being keyed, I could key the transverter, and then I could key the transmitter. This is a very rudimentary form of sequencing and is very easy to implement. When I'm not using the radio as an IF rig, I just unplug the microphone from the RJ-45 connector and plug back into the rig.

I then used a separate I/O line on the BASIC stamp for each transverter as a PTT line. With the system running, you can tell the radio doesn't key instantly, but the lag is very minimal and not something that alters operations.

Contest Performance

With the noted exception of having display problems with the 2-meter amplifier on, the systems works very well. The final setup as run in the NTMS/RMG 902 and Above contest in 2005 is shown in photos 5 and 6. I find that when I go to run the bands with a fixed station, I can switch bands and be on frequency ready to go much faster than any fixed station I have worked to date. In all fairness, many fixed stations have TWT and tube amplifiers on some of the bands. These take time to warm up, and you would not want to leave them on due to the heat generation. All of the amplifiers I have are solid state and require no warm-up.

More Enhancements

Although I'm very pleased with what I have now and it is a very capable contest station, there are always things that can be improved. For the January 2006 VHF Sweepstakes contest, I built the LCD display shown in photo 7 with a few control buttons in lieu of the touch-screen display. I had a band-up and band-down button that allowed me to quickly shift between bands, and my control head was significantly smaller than the Fluke 1780A. My Dad, W5TX, and I used this with great success, until it failed part way through the contest in our rent-a-rig shown in photo 8! Against some advice I was given, I opted not to worry too much about RF getting into the control head. While operating, the display blanked from high RF and I was unable to resurrect it. For the remainder of the contest I controlled the system through the serial port via a laptop, which worked fine.

I am currently debating what I want to do next with the display. I have a touch-screen laptop in the truck, and it would be easy to write a front-end to by BASIC stamp controller that would work on the display. However, this often would require switching applications between logging and transverter control on the laptop, and I have concerns that this would be burdensome. Another option to all of the fancy display and buttons would be a radio-only control system. By this, I mean that just the IF rig would be used for control. For example, if the IF rig were on 440 and you hit the band-up button, the radio would roll around to 1.8 MHz (on my Yaesu it works this way). If I saw this happen, I could put the radio on 144 MHz and switch on the 902 transverter. At this point, the next band-up would go to 440, and again I would put it back on 144 MHz and switch to the 1296 transverter. I've tried to find a way to display 902 MHz directly on the radio, but I've had no success. The 857D has a transverter function and will display up to 10 GHz in the display, but I've had no luck in locating any CAT commands to control this functionality remotely. Therefore, the challenge in doing this is how to indicate the band you're on. I'm working on this problem, although my next project will likely be to run all of my hardware from the MW-520 touch-screen computer in the truck.

My current system also doesn't save the mode. The mode is controlled separately on the radio itself, and if I switch to CW, as I run up the bands, the radio stays in CW. This has not proven to be a major problem, but there may be some utility in saving the mode per band and switching the mode along with the band. This is easy to accomplish, as all of the functionality is available on CAT; it's a simple matter of programming.

One of the final enhancements I'm considering is implementing a few memories per band. On the higher bands I don't think there's a lot of use for this in Texas. There is just not a pile-up on 3456 in Texas. On 2 meters, though, it would be nice to be able to save the calling frequency, a liaison frequency, etc., and be able to quickly switch between all of these.

Photo 8. WDØACD/K5FOG (left) and N5AC/W5TX roving during the January 2006 VHF Sweepstakes.

QUARTERLY CALENDAR OF EVENTS

Current Contests

ARRL June VHF QSO Party: The dates for this contest are June 10–12. Complete rules are in the May issue of *QST*. Rules can also be found on the ARRL website (http://www.arrl.org). Many are making plans to activate rare grids. For the latest information on grid expeditions, check the VHF reflector (vhf@w6yx.stanford.edu) on the internet. This is a very popular VHF contest. For weeks in the run up to the contest postings are made on the VHF reflector announcing Rover operations and grid expeditions. It is a contest that will create for you plenty of opportunities to introduce the hobby to friends who are not presently working the VHF-plus bands or are not hams.

SMIRK Contest: The SMIRK 2006 QSO Party, sponsored by the Six Meter International Radio Klub, will be held from 0000 UTC June 17 until 2400 UTC June 18. This is a 6-meter-only contest. Exchange SMIRK number and grid square. Score 2 points per QSO with SMIRK members and 1 point per QSO with nonmembers. Multiply points times grid squares for final score. Awards are given for the top scorer in each ARRL section and country. Please note that the rules have changed for this year's contest. In particular, the .150 rule has been eliminated. Also, the person to whom you send your logs has changed. Please send a legal-sized SASE for a copy of the log forms. Logs and log requests should be sent to: Dale Richardson, AA5XE, 214 Palo Verde Dr., Kerrville, TX 78028. Entries must be received by August 1. For more information go to <http://www.smirk.org> and click on the SMIRK Contest link at the top of the page.

Field Day: The ARRL's classic, Field Day, will be held on June 24–25. Complete rules for this contest can be found in *QST* and at <http://www.arrl.org>. In years past, tremendous European openings have occurred on 6 meters. Also, as happened in 1998, tremendous sporadic-*E* openings can occur. Certainly, this is one of the best club-related events to involve new people in the hobby.

Six Club Contest: The Six Club Contest runs from 1800 UTC July 8 to 2100 UTC July 9. All logs are due 30 days from end date of the contest and they go either by e-mail, fax, or snail mail to: Mike Urich, KA5CVH, Six Club Contest Director, 9807 Oakmont Dr., LaPorte, TX 77571; fax: (281) 867-9416; e-mail: <contests@6mt.com>. For further information go to <http://6mt.com/contest.htm>.

CQWW VHF Contest: This year's CQ WW VHF Contest will be held from 1800 UTC July 15 to 2100 UTC July 16. The rules can be found at <http://www.cqww-vhf.com>, <www.cq-amateur-radio.com>, and in the June issue of *CQ* magazine.

There are two important contests in August. The **ARRL UHF and Above Contest** is scheduled for August 5–6. Complete rules can be found in the July issue of *QST*. The first weekend of the **ARRL 10 GHz** and above cumulative contest is scheduled for August 19–20. The second weekend is September 16–17. Complete rules for this contest also can be found in the July issue of *QST*.

Quarterly Calendar

The following is a list of important dates for EME enthusiasts:

May 5	First Quarter Moon.
May 7	Moon Apogee. Moderate EME conditions.
May 13	Full Moon.
May 14	Poor EME conditions.
May 20	Last Quarter Moon.
May 21	Good EME conditions.
May 22	Moon Perigee.
May 27	New Moon.
May 28	Poor EME conditions.
June 3	First Quarter Moon.
June 4	Moon Apogee. Moderate EME conditions.
June 11	Full Moon. Very poor EME conditions.
June 16	Moon Perigee.
June 18	Last Quarter Moon. Good EME conditions.
June 21	Summer Solstice.
June 25	New Moon. Poor EME conditions.
July 1	Moon Apogee.
July 2	Moderate EME conditions.
July 3	First Quarter Moon.
July 9	Very poor EME conditions.
July 11	Full Moon.
July 13	Moon Perigee.
July 16	Good EME conditions.
July 17	Last Quarter Moon.
July 23	Poor EME conditions.
July 25	New Moon.
July 29	Moon Apogee.
July 30	Moderate EME conditions.
Aug. 2	First Quarter Moon.
Aug. 6	Very poor EME conditions.
Aug. 9	Full Moon.
Aug. 10	Moon Perigee.
Aug. 13	Good EME conditions.
Aug. 16	Last Quarter Moon.
Aug. 20	Poor EME conditions.
Aug. 23	New Moon.
Aug. 26	Moon Apogee.
Aug. 27	Poor EME conditions.
Aug. 31	First Quarter Moon.

—EME conditions courtesy W5LUU.

Current Conferences and Conventions

Dayton Hamvention®: The Dayton Hamvention® will be held as usual at the Hara Arena in Dayton, Ohio, May 19–21. For more information, go to <http://www.hamvention.org>. N6CL is scheduled to be one of the speakers for the VHF forums, and CQ Communications will have its booth in the main arena.

The annual **Ham-Com Hamfest** will be held June 9–10 in their new location in Plano, TX. As always, the North Texas Microwave Society will present a microwave forum. For details, see the Ham-Com website at <http://www.hamcom.org/>.

This year's **Central States VHF Society Conference** will be held in Bloomington, Minnesota, July 28-29, at the Ramada Mall of America. For more information, go to <http://www.csvhfs.org/CSVHFS2006.html>.

EME Conference 2006: This conference will be held in Wuerzburg, Germany on August 25–27. For more information, go to <http://www.eme2006.com>.

Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers, or for papers to be published in the conferences' *Proceedings,* or both. For more information, questions about format, media, hardcopy, email, etc., please contact the person listed with the announcement. The following organizations or conference organizers hve announced a call for papers:

The **Central States VHF Society Conference**: The Central States VHF Society is soliciting papers, presentations, and posters/tabletop displays for the 40th Annual CSVHFS Conference to be held in Bloomington, Minnesota (across from the Mall of America) on July 28–29. Papers, presentations, and posters on all aspects of weak-signal VHF and above amateur radio are requested. Deadline for submissions: for the *Proceedings,* May 1; for presentations at the conference and for notifying them that you will have a poster to be displayed at the conference, July 3 (bring your poster with you on the 27th of July). Further information is available at the CSVHFS website (http://www.csvhfs.org). Also available are the following: "The 2006 Conference," and "Guidance for *Proceedings* Authors," "Guidance for Presenters," and "Guidance for Tabletop/Poster Displays." Contacts: Technical Program Chairman, Jon Platt, WØZQ, at <W0ZQ@aol.com; *Proceedings* Chairman, Donn Baker, WA2VOI/Ø at <Proceedings.WA2VOI@OurTownUSA.net>.

EME Conference 2006: To be held in Wuerzburg, Germany on August 25–27, interested authors are invited to present a paper(s) for the conference. Electronic submissions in Word®97, Word®2000, Acrobat®5 (PDF), or text format will be accepted by e-mail or CD. Please ask if you are using another format. If you are interested in writing and/or presenting a paper, send an e-mail to Rainer Allraun, DF6NA, at <df6na@df6na.de>. Please contact him as soon as possible with an abstract or even a general idea. This will help the conference team with its planning activities. For more information about the conference go to <http://www.eme2006.com>.

ARRL and TAPR Digital Communications Conference: Technical papers are solicited for presentation at the 25th Annual ARRL and TAPR Digital Communications Conference to be held September 15–17 in Tucson, Arizona. These papers will also be published in the conference *Proceedings* (you do *not* need to attend the conference to have your paper included in the *Proceedings*). The submission deadline is

(Continued on page 83)

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

"The Listeners" (2004 edition), by James Gunn

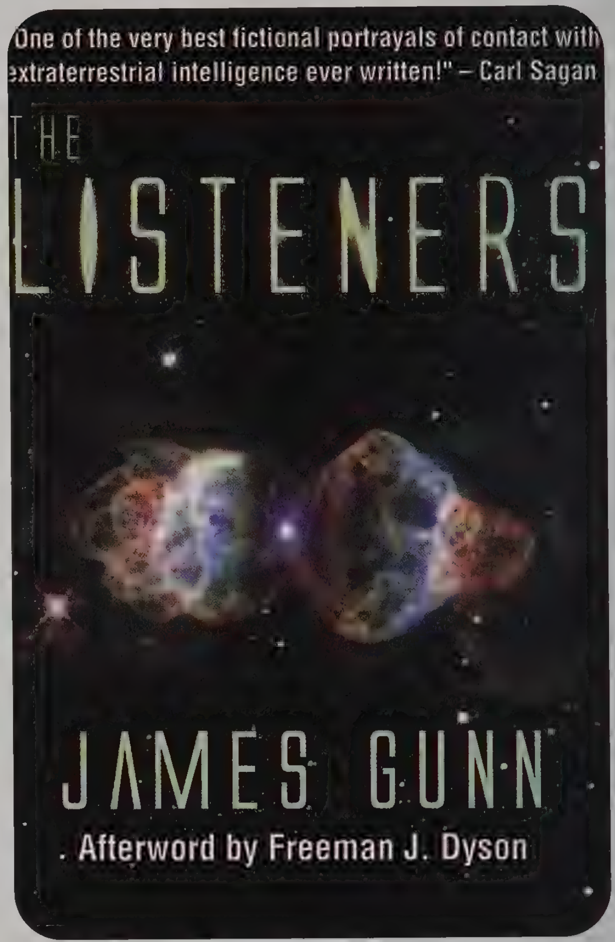
The search for intelligent signals from space was the lonely life's work of Robert MacDonald. Today, he would not be quite so alone, as many of us have been privileged to follow in his fictional footsteps. Indeed, in the three decades since *The Listeners* was first published, SETI has grown from an obsession of a handful of scientists working on the fringe into a household word pursued by literally millions of amateur and professional enthusiasts. However, we have yet to uncover the Call from Capella, which was central to the plot of this science-fiction classic. Perhaps we never will.

The widespread public interest and support which SETI now enjoys is indeed a tribute to human optimism. It also speaks volumes about Gunn's novel, recently reissued by BenBella Books, of Dallas, Texas (2004 ISBN 1-932100-12-1, $14.95 [trade paperback], available through The SETI League, Inc. Order online at <http://www.setileague.org/ photos/premiums.htm>). This is the book that inspired a generation of SETI scientists to pursue the seemingly impossible. Many of us decided early on that we wanted to be Robert MacDonald when we grew up, and if we ever do grow up, one or more of us may someday achieve that goal.

The SETI Institute's Tom Pierson notes in an insightful introduction to this new edition that the growth in our technological prowess since Jim Gunn first penned this book has been astronomical. Our searches today are just beginning to approach the sensitivity of Big Ear (Gunn's fictional space-based one, not the recently demolished radio telescope of the same name at Ohio State University). Our computerized signal-analysis hardware and software are expanding the search space to include most of the microwave spectrum, as well as significant segments in the infrared and optical regions. Soon the entire electromagnetic realm will reveal its secrets to us. All we need to do is wait . . . perhaps, as MacDonald did, for most of our lives.

More important, maybe, than our technological prowess is our societal progress, for the notion of humankind's uniqueness in the universe is falling into disfavor (due, in large part, to this very novel!). The idea that we are but one civilization among the many is fast becoming the accepted paradigm. For my children's generation, the burning question is no longer *whether* we will achieve contact with our cosmic companions, but rather *when.*

A major shift in funding has occurred in the years since *The Listeners* first saw print. What Jim Gunn envisioned as a massive government-sponsored project has gone grass-roots. Indeed, since the lamented day a dozen years ago when Congress cancelled the NASA SETI program, thousands of radio amateurs and signal-processing experimenters have turned their own modest back-yard dishes toward the stars.



The Listeners *(2004 edition) by James E. Gunn and published by BenBella Books, Dallas, Texas. Jim Gunn's inscription inside my personal copy reads: "To Paul, for helping to realize what I only imagined." Although not himself a radio amateur, Gunn clearly understands the importance and significance of amateur SETI.*

Millions of ordinary citizens have lent their spare computer cycles to the process of analyzing data from the world's greatest radio telescope (the very one Robert MacDonald used in Gunn's story). Also, a handful of dedicated industrialists have financed the design and construction of arrays grander and more sensitive than those contemplated in fiction. SETI is truly the science that refuses to die.

We who dedicate our lives to "The Search" well realize that ours may be, like MacDonald's, a multi-generational effort. We can only dream large, as Jim Gunn has taught us to do, and count the days (or centuries) until our dreams are realized.

73, Paul, N6TX

**Executive Director, The SETI League, Inc.,*
<www.setileague.org>
e-mail: <n6tx@setileague.org>

Advertisers' Index

CALENDAR *(from page 81)*

July 31. Papers should be sent to: Maty Weinberg, ARRL, 225 Main St., Newington, CT 06111, or you can make your submission via e-mail to: <maty@arrl.org>. Papers will be published exactly as submitted and authors will retain all rights.

Current Meteor Showers

May: May minor showers include the following along with their possible radio peaks: *ε-Arietids,* May 9, 1300 UTC; May *Arietids,* May 16, 1400 UTC; and *o-Cetids*, May 20, 1300 UTC.

June: Between June 3 and 11, the *Arietids* meteor shower will once again be evident. This is a daytime shower with the peak predicted to occur on June 7 at around 1600 UTC. Activity from this shower will be evident for approximately eight days, centered on the peak. At its peak, you can expect around 60 meteors per hour traveling at a velocity of around 37 km/sec (23 miles per second).

On June 9 the *Zeta Perseids* is expected to peak at around 1600 UTC. At its maximum, it produces about 40 meteors per hour. The *Boötids* are expected to make a showing between June 26 and July 2, with a predicted peak on June 27 at around 1400 UTC. On June 29 the *Beta Taurids* is expected to peak. Because it is a daytime shower, not much is known about the stream of activity. However, according to the book *Meteors* by Neil Bone, this and the *Arietids* are two of the more active *radio* showers of the year. Peak activity for this shower seems to favor a north-south path.

July: This month there are a number of minor showers. The most intense, the *delta-Aquarids,* is a southern latitude shower. It has produced in excess of 20 meteors per hour in the past. Its predicted peak is around July 28.

August: Beginning around July 17 and lasting until approximately August 14, you will see activity tied to the *Perseids* meteor shower. Its predicted peak is around 2300–0130 UTC between August 12–13. According to the International Meteor Organization: "Simulations by Peter Brown made some years ago suggest enhanced *Perseid* activity is possible this year, though perhaps not as strongly as in 2004. The timing of any enhancement, though probably not far from the expected spread of possible maxima noted here, is not known."

For more information on the above meteor shower predictions see Tomas Hood, NW7US's propagation column. Also visit the International Meteor Organization's website: <http://www. imo.net/calendar/2006/>.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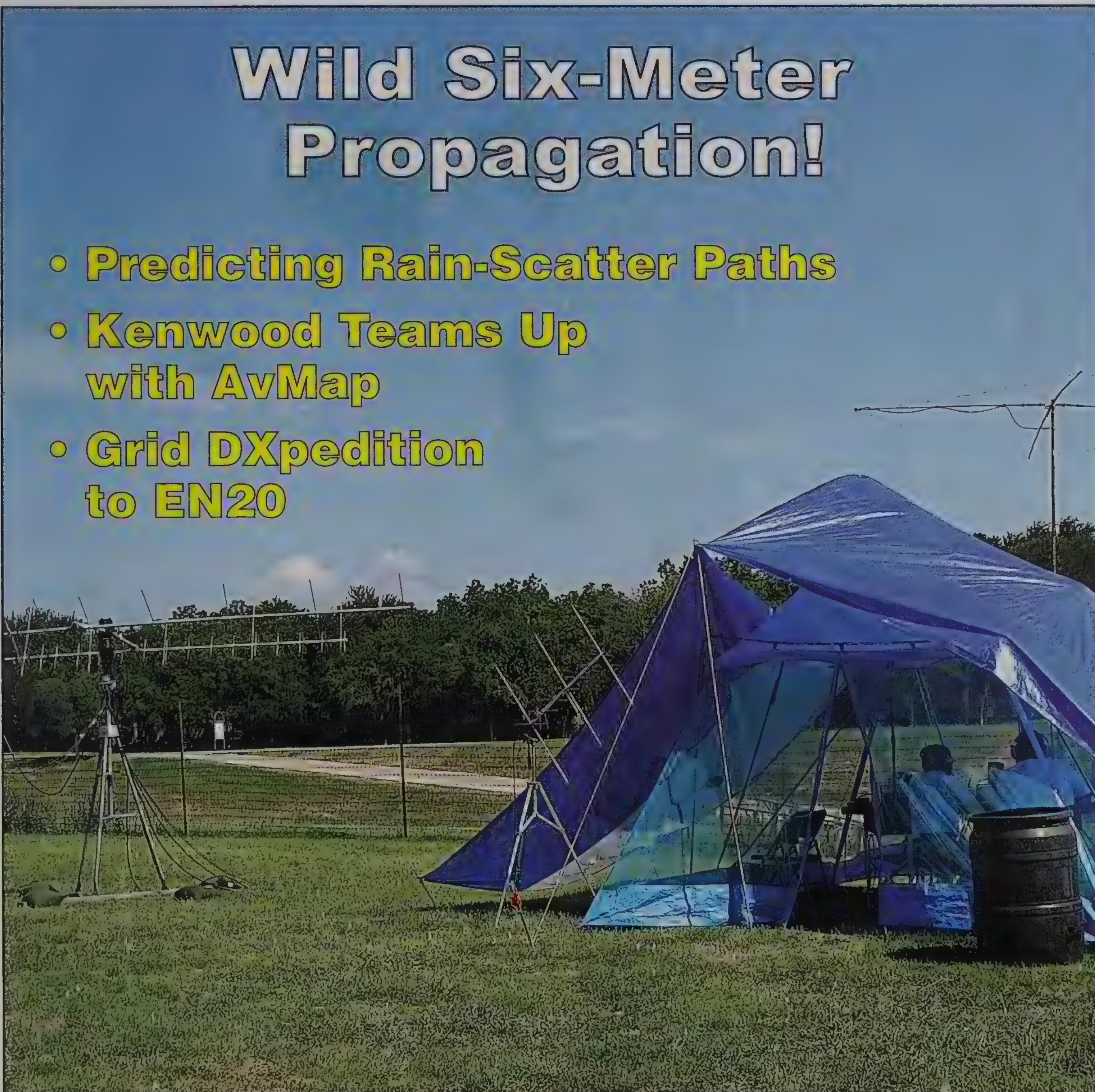

■ VHF/UHF Weak Signal ■ Microwaves ■ Amateur Satellites ■ Repeaters ■ Packet Radio ■ Projects ■ Interviews ■ Plus...Reviews, Product News, and much more!

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FEATURES

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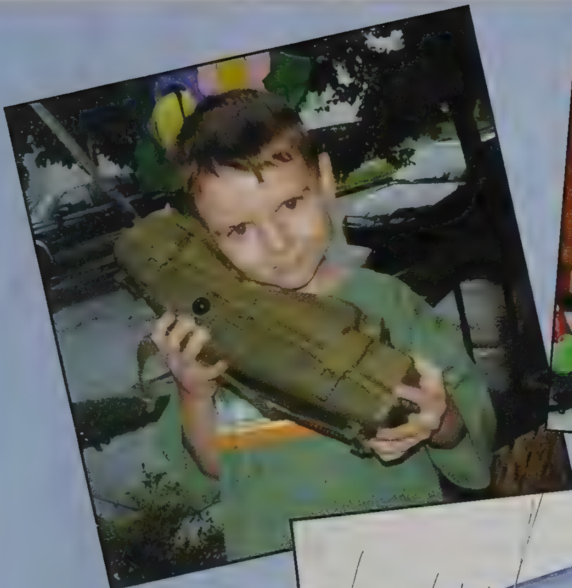

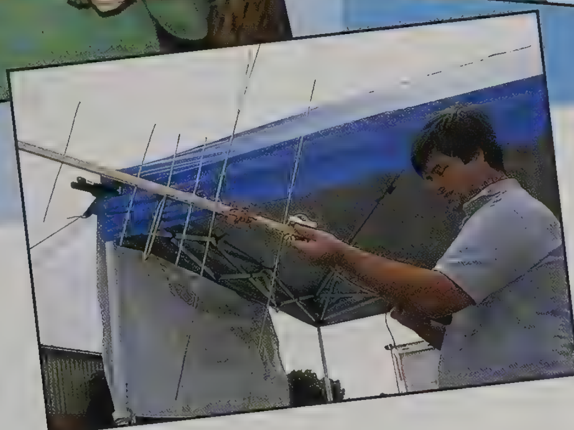

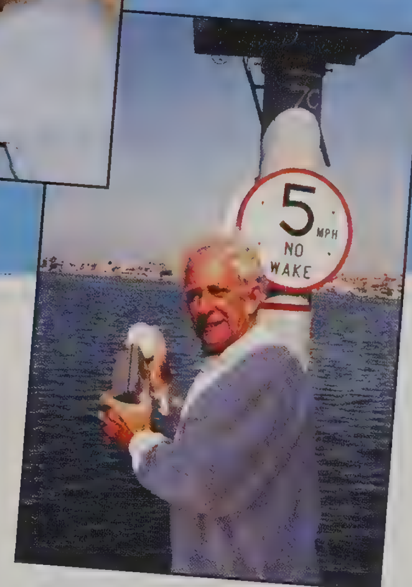

COLUMNS

DEPARTMENTS

On The Cover: ARRL Field Day 2006 and the accompanying AMSAT Field Day were held on 24–25 June. This year activity was limited to ISS, AO-51, SO-50, AO-27, FO-29, VO-52, and AO-7. For details, see the "Satellites" column on p. 44. (Photo by Keith Pugh, W5IU)

CQ VHF Ham Radio Above 50 MHz

A Message from the Editor

The APRS Thread

We are now midway through the fifth year of the reintroduced version of *CQ VHF* magazine, and my mind can hardly keep up with the ever-expanding use of the VHF-plus frequency spectrum. As many of you know from reading my VHF column in *CQ* magazine, my background is in weak-signal communications. Those of you who are long-time readers of the column will have noticed that since taking on the responsibilities of editing this magazine, my coverage of VHF activities has greatly expanded beyond weak-signal communications. In fact, occasionally there are columns in which I have very little weak-signal coverage. This is because the increased interest in the VHF-plus ham bands has fractionalized into many different uses for the spectrum.

Ironically, we who are active on these bands are finding some commonality in one particular form of communications—APRS (Automatic Position Reporting System). APRS is increasingly being used for a number of VHF-plus activities, in some respects becoming the thread that weaves itself throughout our use of the VHF-plus spectrum. APRS has become a method used by bicycling-event organizers for tracking locations of lead cyclists and emergency vehicles, such as ambulances. APRS is used by balloonists to track their balloons as well as track various chase vehicles as these teams triangulate the balloon's location for recovery of its payload. APRS is being used by microwave enthusiasts for more precise aiming of their antennas for making record-setting mountaintop QSOs. In short, APRS continues to weave its way into more and more of our use of the VHF-plus spectrum.

Two articles in this issue feature APRS applications. Carlton Doe, W3DOE, describes how to build a simple APRS tracker, beginning on page 15. Gordon West, WB6NOA, reviews the marriage between Kenwood's D-7 and D-700 and AvMap's Geosat 4 beginning on page 20.

CubeSats and AMSAT

On July 26 or 27, more than a dozen miniature satellites from ten universities and one company were scheduled to be launched into orbit via a Dnepr-1LV rocket that was to carry the CubeSats into space from the Baikonur Cosmodrome in Kazakhstan. The following is from the *ARRL Letter* (June 8, 2006) and describes the CubeSat program:

The CubeSat project is a collaboration between California Polytechnic State University-San Luis Obispo and Stanford University's Space Systems Development Laboratory. All of the CubeSats set to launch this month were designed and built by students at various universities in the US and elsewhere in the world.

Cornell University, Cal Poly, and the University of Arizona each will send two CubeSats into space. Other US schools participating in the mass CubeSat launch are the University of Illinois, the University of Kansas, Montana State University, and the University of Hawaii. In addition, schools in Norway, South Korea, and Japan have built CubeSats for this month's launch.

One of the CubeSats, known as SEEDS, was built by students at the Nihon University in Japan. It contains a CW beacon, Digi-Talker, and other experiments. The CW beacon will be on 437.485 MHz and use the callsign JQ1YGU. The Digi-Talker experiment will be activated later. All 13 CubeSats will identify using amateur radio callsigns.

According to AMSAT-NA, the satellites will be put into a 500-by-566 km (310 by 351 miles) orbit with a 97-degree inclination. Each tiny satellite is a 10 cm (4 inch) cube weighing just 1 kg (2.2 lbs) into which the battery, transmitter, and various experiments are packed.

Twelve of the satellites have downlinks in the amateur radio satellite allocation between 435 and 438 MHz, and one will operate on 145.980 MHz, so there will be lots of signals to listen out for after launch. None of the spacecraft will carry a transponder. Transmitter power outputs range from 10 mW to 2 W.

A complete list of the satellites can be found in the Satellite column, which begins on page 44. Ralph Wallo, WØRPK, maintains a website with up-to-date information on the CubeSats. The URL is: <http://showcase.netins.net/web/wallio/CubeSat.htm>. Paul Shuch, N6TX, gives some insight into the CubeSat program in his Orbital Classroom column, which begins on page 42. Perennial antenna designer Kent Britain, WA5VJB, has some "Cheap Yagis" that can be used for communicating via these satellites. You can find these designs beginning on page 28.

Speaking of AMSAT, in this issue's Satellites column Keith Pugh, W5IU, discusses the plans AMSAT has for future launches. In the near term the P3-E satellite is gearing up to be launched in 2007 or 2008, depending upon availability of a launch vehicle. Unique to this satellite will be the use of a software-defined transponder (SDX). Among the benefits from using the SDX are mode versatility, low power consumption, and a major improvement in interference and "Alligator" immunity. The latter is accomplished by way of the inclusion of auto-notching software known as STELLA (Satellite Transponder Equalizing Level Limiting Adaptor). This software is designed to reduce multiple high-level "spikes" without affecting the transponder noise floor and low-level signals.

In the long term, AMSAT is designing the Eagle satellite. Thanks to *EaglePedia,* an open forum available on the AMSAT website (http://www.amsat.org), any AMSAT member can view most design details of the satellite while it is being developed.

Remembering Two of Our Comrades

Tragically, Mike Obermeier K6SNE, and David Gordon-Ross, N6IDF, lost their lives when Mike's Jeep went off a mountain road near Lake Isabella in Kern County, California on May 27. The two of them were on a hidden transmitter hunt over the Memorial Day weekend. Homing In columnist Joe Moell, KØOV, gives a moving and sensitive tribute to these two members of our amateur radio community. His column begins on page 24.

Every time we in our ham radio community learn of the loss of life of one of our members, no matter what the cause, we need to pause and reflect on the fact that we do participate in a hobby that has some inherent dangers. In reflecting on this fact, we also need to give some thought to how we can play it safe while participating in our wonderful hobby. Until the next issue…

73 de Joe, N6CL

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- Battery-drain function avoids memory-effect
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Six Meters Goes Wild!

Regular operators on the magic band were treated to extraordinary propagation this past June. Here Contributing Editor WB2AMU summarizes some of the numerous openings experienced by North American 6-meter operators.

By Ken Neubeck,* WB2AMU

During the summers of 2004 and 2005, sporadic-*E* conditions were modest at best for the months of June and July for much of North America. Some stations in the northern part of New England and in eastern Canada saw very little transatlantic sporadic-*E* conditions into Europe. There were long droughts of sporadic-*E* activity in general.

Part of the reason for the reduction of sporadic-*E* during the past two summers may have been the presence of moderate-to-high geomagnetic activity that resulted in aurora activity during those months. Typically, unless an intense aurora occurs, high geomagnetic activity seems to be a deterrent for sporadic-*E* activity. (This will be the subject of an upcoming article for *CQ VHF* written by Jon Jones, NØJK, and me.)

With virtually a handful of sunspots occurring during the first half of 2006, along with limited geomagnetic activity, there seemed to be the potential for a decent sporadic-*E* season beginning in May. During the winter sporadic-*E* season, activity was good for the southern tier of the United States, but for the higher latitudes there was minimal activity on 6 meters. Thus, there was a hopeful expectation that things would be better for the summer.

During May there were a number of decent openings between the U.S. and the Caribbean, as well as between the U.S. and Europe. One station that was worked quite a bit during May by stations in parts of the U.S. was EH8BPX, Avelino, in the Canary Islands. Also, a few expeditions to the Caribbean took place, such as one conducted by Howard Sine, WB4WXE, to Antigua, V26 during the first week of June, and the one conducted by Chris, W3CMP, to Haiti during the third week of June.

Howard reported that June 4th was his best day, with 29 states and 11 countries worked. He gave several VE's, as well as W3EP, a new country using a three-element Yagi and 100 watts (photo A). Some of the VE stations that Howard worked via two-hop were VE1YX, VE2CTU, VE2XK, VE2DFO, VE3GIB, VA3DX, VE3XN, and VE3IC. As you can see in photo A, Howard's three-element Yagi was hooked up to an ICOM IC-706 running barefoot.

Japan to the U.S. on 6 meters!

During the first week of June, however, a really incredible occurrence took place on 6 meters. On the evening of June 4th, a number of stations in Texas hooked up with Japan! One was Alan Benoit, WQ5W, and here is what he had to say:

Photo A. Here is the three-element Yagi antenna setup of Howard Sine, WB4WXE, during his trip to Antigua as V26HS. Howard had one really good day of propagation (June 4th) and two decent days during his one-week stay. The longest distances he worked were to VE7SL (CN 88), W7CE (CN 87), and W7MEM (DN 17). (Photo courtesy of WB4WXE)

The prelude to the opening was pretty normal. Sunday morning we had a nice stateside opening, and EH8BPX was readable for a few hours straight. We had QSOs at 1446Z and 1729Z. Several 5's also reported working into CT3 and CT, but I couldn't hear them. In the afternoon the band opened to the Caribbean, and I worked FY1FL for a new one at 21:51Z.

What happened next was the most incredible thing I have ever experienced on 6 meters. I was about to shut down the rig and go out for the evening when I checked the DX cluster one final time at around 5:15 PM local (2200Z). I noticed with interest that NL7Z in Alaska was being worked in west Texas on SSB. I had only worked one KL7 on 6 meters ever before, and that QSO was after midnight local time, so I had to

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Photo B. Jon Jones, NØJK, with the portable two-element, 6-meter Yagi he used to work JA7QVI from the roof of a parking garage where he works. Plans for this Yagi are in the book "Six Meters, A Guide to the Magic Band" by WB2AMU (Worldradio books). (Photo courtesy of NØJK)

give a listen to see if I could hear him. Sure enough he was a solid 5-7 and he responded to my call immediately.

I then saw on the chat.dxers.info 6-meter chat room page that JH2COZ was going to call CQ on 50.096 CW. I had never worked or even heard a JA on 6 meters, so I didn't think much of it. But I figured what the heck, I'd listen for a couple of minutes before heading out the door. So I tuned to 50.096, and to my amazement there was JH2COZ calling CQ a solid 559. I gave him a call and he came back immediately. I had worked my first JA ever! I then went up the band and started calling CQ and had many JA's come back to me! Over the next 3 hours, 24 minutes I worked 42 JA stations in 10 different grids! The signals were on the weak side in many cases, but all were solid Q5 copy. They were much stronger and more readable than the often ESP copy we get on EU stations from here. It felt and sounded very much like the 10-meter JA runs we get in contests at the top of the sunspot cycle.

A couple of times during the run I thought it was over, only to have more JA's come back to my CQ's a few minutes later. In between the JA's, I also worked KL8DX and several VE7's. I worked my last JA at 0151Z. It was a great experience, sharing the thrill of this opening with the guys in the chat.dxers.info 6-meter chat room. They seemed to be as thrilled and amazed as I was about this, and their encouragement and kind words made the experience even better!

I use two M^2 6M7JHV seven-element (30-foot boom) Yagis at my QTH on different tow-

(Continued on page 73)

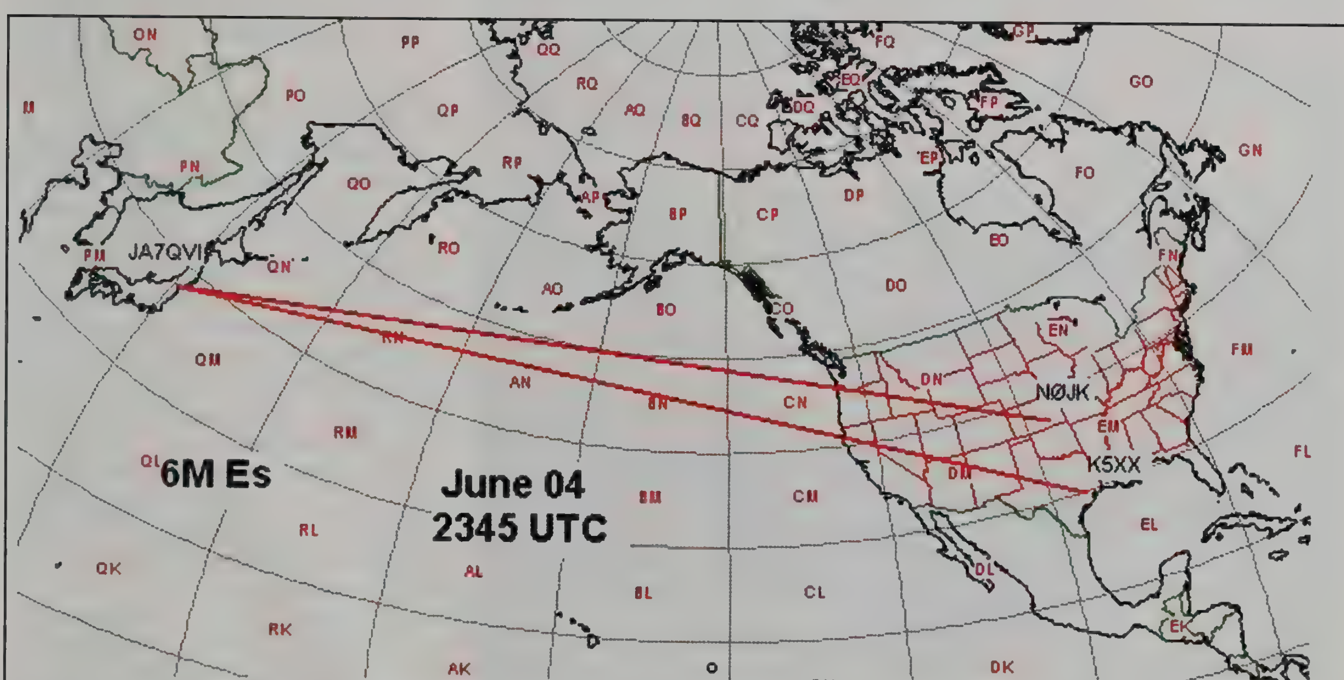


Figure 1. Jon Jones, NØJK, created this figure, which it shows the path between stations in Japan and stations in Texas and Kansas during the June 4th opening.

Grid DXpedition to EN20

KX9X and NM9H activated rare grid EN20 for the duration of this year's ARRL June VHF QSO Party. They hope their grid DXpedition experiences, presented here, will encourage others to do the same.

By Sean Kutzko,* KX9X

The following is a recap of the KS9Z/Ø grid DXpedition to EN20, which took place from June 9–12, 2006. This DXpedition was timed to coincide with the ARRL June VHF QSO Party. Matt Kolb, NM9H, and I were the operators. In contrast to a rover operation, Matt and I activated a specific, rare grid for the entire contest period, and then some. We hope that our experiences will encourage others also to go on grid DXpeditions for the purpose of activating rare grids for extended periods of time.

This was to be our first grid DXpedition in four years. We made a conscious decision to get back into things slowly, so we chose to use smaller beams on the high bands, reducing the amount of packing we had to do, and left the kilowatts at home in favor of simple bricks. We also only went out for essentially three days of operating.

**e-mail: <kx9x@yahoo.com>*

Friday, June 9

We hit the road at 4:30 AM from EM59. We arrived at the KOA campground in Rock Port, Missouri in EN20 at around 11 or so that morning. Our hosts, Annette and Dave, were delighted to see us and couldn't have been nicer. They made us feel very welcome and showed us to the small cabin we've grown accustomed to renting for these trips. It is 12' × 12', has one double bed (which served as the operating surface), and two sub-twin-size bunk beds. It is out of the elements and has air conditioning and electricity. It is all we could have asked for.

We started setting up upon arrival. It was hot (91 degrees), with bright sunshine and no shade. We took several breaks while getting the antennas up. By late afternoon, we had 6 meters and 2 meters up and running. Matt fired up some bratwursts on the grill while I started working 6 meters. Our first QSO was with WA7FPO in DM54 at around 2200 UTC.

Our first disappointment occurred when Matt took out his laptop to check his e-mail. We found no nodes to hit. We were told the site had wireless internet, so Matt asked if there was a problem. Indeed there was; it hadn't been working for a couple days and there wouldn't be a tech out to look at it until Monday! This put a *major* crimp in our plans. We were hoping to be able to check the prop loggers for info on band openings, and I had made a sked with one ham who badly needed EN20 on 6 meters. I didn't write down any of his information, since I figured I'd just get it from his e-mail. That was a big mistake, one that cost a ham a grid, and I'll never do that again.

During the early evening we worked a handful of stations to the southeast around EM73. After that run of stations we decided that even though it was early, we were tired and dehydrated, so we ended up going to bed at around 10 PM.

Saturday, June 10

We got up at around 8 AM, had breakfast, and set to work getting up the mast for the 222- and 432-MHz antennas. I worked a few folks on 6 meters in between measurements. The antennas assembled easily; 222 sounded great, but 432 didn't. Here was our second disappointment: We realized that we had forgotten the SWR analyzer *and* the SWR meter in our early morning rush out the door. Big bummer!

Matt set out to figure out what was up with the UHF bands while I worked 6 meters. We had a great opening Saturday morning to the east and southeast (FM29, EM84, FN10, etc.).

By contest time, we had taken the 432-MHz beam apart and re-adjusted it. It sure sounded better, but we had no way of checking SWR. By the time the contest started, I'd put in about 75 QSOs on 6 meters.

The cabin at the Rock Port, Missouri KOA, our site for the ARRL June VHF QSO Party EN20 grid DXpedition.

CQ Contest!

Six meters started off with a *bang,* working huge openings and big pile-ups into a single-hop radius to Maryland, Delaware, Pennsylvania, Michigan, and Ohio. We logged 88 QSOs in the first hour. The band was cooking and cooking hard!

Matt made a Q with NØWL in EN21 on 2 meters. He said we were weak. Uh oh. We tried 432 MHz with him, but he never heard us and we never heard him. Uh oh again!

I kept working guys up and down the East Coast, and every now and then I'd work somebody out west off the back of the beam. Propagation stretched up into New England at around 2200 UTC, and then got short again at around 2315 UTC. At around 0200 UTC I worked several stations out west, in Colorado and New Mexico. Matt tried to work guys on 2 meters, but was not successful. We heard NØWL talk about the sporadic-*E* he was working out to the east, but we never heard it at all. At around 0300 UTC 6 meters folded for us. By then I had 273 Qs on 6 meters in the log, which was one of my best 6-meter days ever. On the other hand, 2 meters through 432 MHz were toast, and Matt couldn't determine why.

Sunday, June 11

We woke up at around 7:30 AM on Sunday. Our first Q on 6 meters was FN03 at 1406 UTC. About 30 minutes later, I worked KØDI in DM04, so I swung the 6-meter beam west; it stayed in that direction almost all day. The desert Southwest was the source of the vast majority of QSOs I worked on Sunday, with an occasional Q into EL29 and DN71. Matt was without an operational station on 2 meters through 432 MHz, and had no internet, so he tried in vain to get the bugs worked out. He did work some 6-meter stuff on Sunday, but for the most part, Matt unsuccessfully spent most of his time trying to get the UHF stuff going.

We worked some real close-in stations at around 1700 UTC, including EN52, EN50, and EN61 (home ground of our beloved Society of Midwest Contesters). We swung the beam back west at around 1930 UTC, and it stayed there the rest of the afternoon.

Trouble with TVI

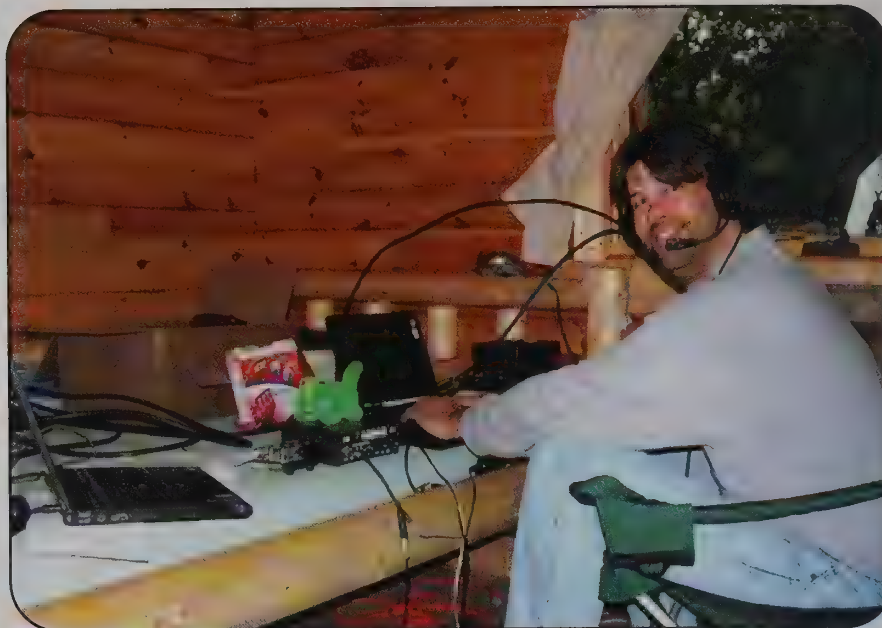
By 6:45 PM the KOA was getting full. As I was working K2DRH on 6 meters CW, I looked out the window of our cabin, directly into the front window of an RV parked right across from us. I could see the elderly lady fiddling with the TV, watching the picture get completely distorted in perfect unison with my CW. When I transferred K2DRH over to Matt (who did work him on 2 meters), Matt's SSB signal on that band was doing more damage to our new neighbor's TV than 6 meters was. I looked out the front door of the cabin and saw the place was full to capacity; it hadn't been that full all weekend!

We didn't want to cause any problems for our host, so we shut down the station. Our last QSO was with K2DRH on 2 meters at 0048 UTC (Monday AM GMT).

We were still pretty wiped out and a bit frustrated at the lack of success on 2 meters and up, so we ate dinner and went to sleep early. We woke up at about 7:30 AM on Monday, took everything down, and were on the road by 11 AM.

The folks at the KOA were *very* supportive and apologized for the lack of internet access. A lot of folks had complained about it. We did our best to keep them up to speed on what we were doing, and how things were going. They were genuinely interested. As we were leaving, Annette asked, "When will you be back?" We said maybe in September. I asked if they'd mind other hams operating from there, and they said they'd be delighted. So if anybody wants to activate EN20 any time soon, the KOA in Rock Port, Missouri would be glad to have you. E-mail me for details if you're interested.

While the incredible conditions on 6 meters salvaged the operation, the lack of QSOs on 2 meters and up has left a sour taste in our mouths. Learn from us: More careful planning is required before operating from rare grids. We felt we should have been able to provide EN20 on the higher bands as well, and we didn't do that. Still, for our first venture in several years, we did okay. We will learn from our mistakes and plan accordingly for the next grid DXpedition.



Sean, KX9X, working the 6-meter pile-ups on Saturday, June 10.

For more information on future grid DXpeditions by the Society of Midwest Contesters, please see the following URL: <http://www.ks9z.com/>. Thanks for the QSOs, everybody!

Summary

6 meters: 412 QSOs, 121 grids
2 meters: 3 QSOs, 3 Grids
222 MHz: 0 QSOs
432 MHz: 0 QSOs
Total: 415 QSOs, 124 grids

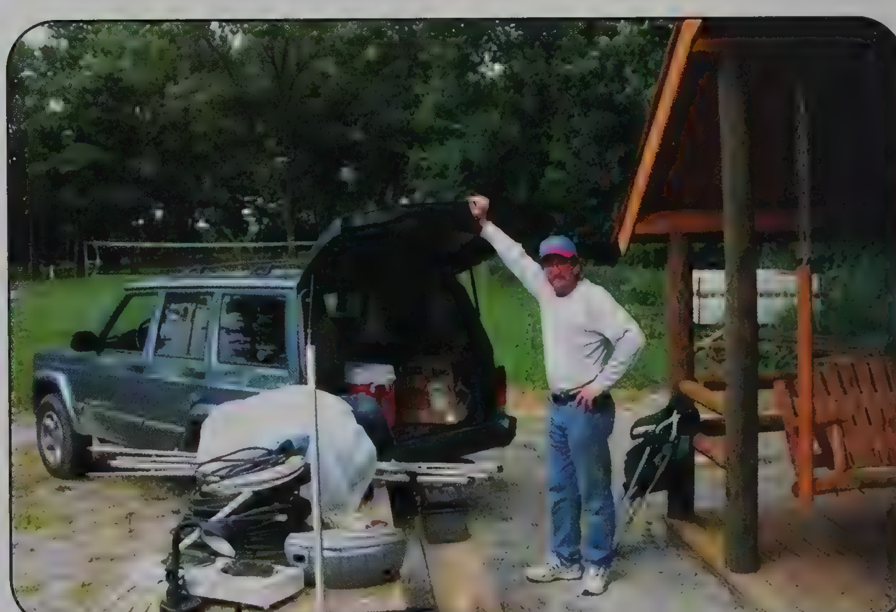
Rigs

6 meters: IC-706mk2, 100 watts, Cushcraft 3-el Yagi up 20 feet.

2 meters: Yaesu FT-736R, 2-meter brick (100 watts), 5-el homebrew Yagi up 20 feet.

222 MHz: Yaesu FT-736R, 222-MHz brick (100 watts), Cushcraft 4-el Yagi up 17 feet.

432 MHz: Yaesu FT-736R, 432-MHz brick (100 w), M^2 11-el Yagi up 20 feet.



Packing up to go back home, Matt, NM9H, stands next to our gear.

Building an APRS Tracker

Part 1 – The “Nimble” Tracker

APRS and GPS are initials that are enjoying increasing popularity among hams who operate on the VHF-plus bands. Here in part one of a two-part article on building APRS trackers, W2DOE describes how he built a simple APRS tracker using a Garmin eTrex GPS receiver, an ICOM IC-T2H handheld, and a TinyTrac3 TNC.

By Carlton Doe,* W3DOE

In an effort to build radio skills as a new ham in 2004, I volunteered for several road races and marathon events. I was told by the communication directors that while they appreciated my efforts, I could be more valuable to them if I had an APRS (Automatic Position Reporting System) tracker. This resulted in my first ham-oriented research and construction project: What was APRS and how would I build what everyone called an “APRS tracker”?

This article will briefly introduce APRS and tell how you can build a simple, low-cost portable tracker. Part 2 will cover construction of a more advanced and powerful tracker. I should explain that as a “bear of very little brain,” I built the harder tracker first before building the one featured in part 1. I did learn a lot in the process, though, resulting in what I think is the simple and elegant “nimble” tracker covered here.

Photo 1. The Garmin eTrex GPS receiver and its cabling.

APRS & APRS Trackers

The Automatic Position Reporting System was developed by Bob Bruninga, WB4APR, as an enhancement to regular packet-mode transmission oriented specifically for publishing location-based information via RF. There are two parts to an APRS system: One part transmits where the tracking object is (the job of a tracker); the second part is the display software which receives APRS transmissions and plots the position information on maps. There are a number of software packages, such as UI-View (www.ui-view.org), that can be used to display APRS data. Some of the packages will only work if connected to a radio through either a software or hardware interface. Other packages are internet-aware and can display APRS information gated by digipeaters to APRS internet-based servers. Digipeaters function like the voice repeaters most of you are familiar with, although they handle packet-mode traffic. As a result, you can have a lower power radio yet still achieve broad distribution of your APRS information.[1] Many APRS digipeaters are linked to internet-based servers which provide a rolling and filterable archive of position reports the software uses to plot on its maps. APRS software will not be covered in either part of this article.

As I researched APRS trackers on the internet, I didn’t find a lot of useful information other than some pictures. What those pictures showed, though, was that a tracker could be built into almost anything! I saw trackers in which their owners threw the components on the seat of their cars. This violated my sense of aesthetics as well as “professionalism” as an operator. I saw others built in small mint tins, discarded ammo cans, coolers, waterproof cases, and various other containers. Some appeared to have additional “bells and whistles,” while others were very basic.

Regardless of how the tracker was built, each had four basic components:

- A Global Positioning Satellite (GPS) receiver to generate the location-based information.
- A TNC (Terminal Node Controller) to interface with a GPS receiver and translate its data stream into a signal that can be transmitted by a radio. The TNC also connects to and controls the radio, determining how often or under what conditions the tracker will “beacon,” or send out, its location information.
- A 2-meter radio able to transmit at 144.390 MHz, the APRS frequency for almost all of the United States.
- An enclosure.

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It became apparent to me that building a tracker would involve balancing a number of factors, and how I weighted each would determine the size, capability, power, and portability of the tracker. For example, a high-RF-power tracker would require a larger radio. If I wanted the tracker to beacon for a long period, I'd need a larger and heavier battery. For a tracker to be easily transportable, it would have to have a small form factor, requiring a lower power radio. There isn't one set of "correct" answers to any of these issues. You as the builder have to decide what you want to do with the tracker, and that will guide the rest of your decisions.

Having built one rather large tracker (covered in part 2), I wanted to build something completely different—what I called a "nimble" tracker, which could be used if I was assigned to shadow a race official or to take with me on a Scout hike through some of the large parks and nature reserves close to where I live. The requirements for this tracker were:

- Simple construction
- Small form factor
- Light, able to be carried around for an entire day
- As inexpensive as possible
- Low(er) transmit power, would rely on digipeaters
- Modular so I could change out a piece if I didn't like it or re-use components should I decide to junk the whole thing

With this in mind, I proceeded to get a radio, TNC, and GPS receiver and hook them together.

The GPS Receiver

This was the area I knew best. I had been using GPS devices for automotive navigation for some time and was very familiar with GPS technology and the various types of receivers available. For this tracker, I wanted a receiver that was small, could be worn on a belt or elsewhere and yet still maintain an excellent lock on satellites, and was somewhat waterproof should the elements change. In my opinion, the only choice was a unit from the Garmin eTrex family of products (http://www.garmin.com/outdoor/products.html). In my opinion, Garmin builds the highest quality, most reliable GPS receivers, and their customer service is second to none.

The eTrex line is quite broad, and any one of the units, including the lowest model, would be perfect for this application. Another advantage is there are plenty of used units readily available on the larger auction and resale websites, so they can be purchased well below what new units cost. Another important consideration is that the eTrex's data port will output a constant stream of position information, as opposed to other highly portable units such as the Foretrex or Forerunner. While these could be used, a specially modified data cable needs to be built to trick the Foretrex/Forerunner into thinking it is attached to a computer requesting a data download. As the first criterion of this project was simplicity, I opted not to build that kind of cable.

As shown in photo 1, I opted to buy an eTrex Vista, even though it wasn't the least expensive model available. The Vista, though, enables the loading and use of highly detailed street-level maps used by my automotive GPS. With this, I can operate in urban events without the need to refer to paper maps; I just glance at the screen of the eTrex. This is definitely an add-on option not required to build a successful tracker. Had I not been able to load my automotive maps without an additional license fee, I wouldn't have purchased the Vista.

Photo 2. The ICOM IC-T2H handheld and the homebrew cable that connects to the TNC.

The Radio

The size, weight, and cost criteria for this tracker required an inexpensive 2-meter handheld. At the same time, it had to be rugged enough to handle the abuse of being bounced around in a fanny or day pack for the day. The ICOM IC-T2H

Photo 3. The modified Serpac C6 case housing the TNC board, along with the 9-volt battery.

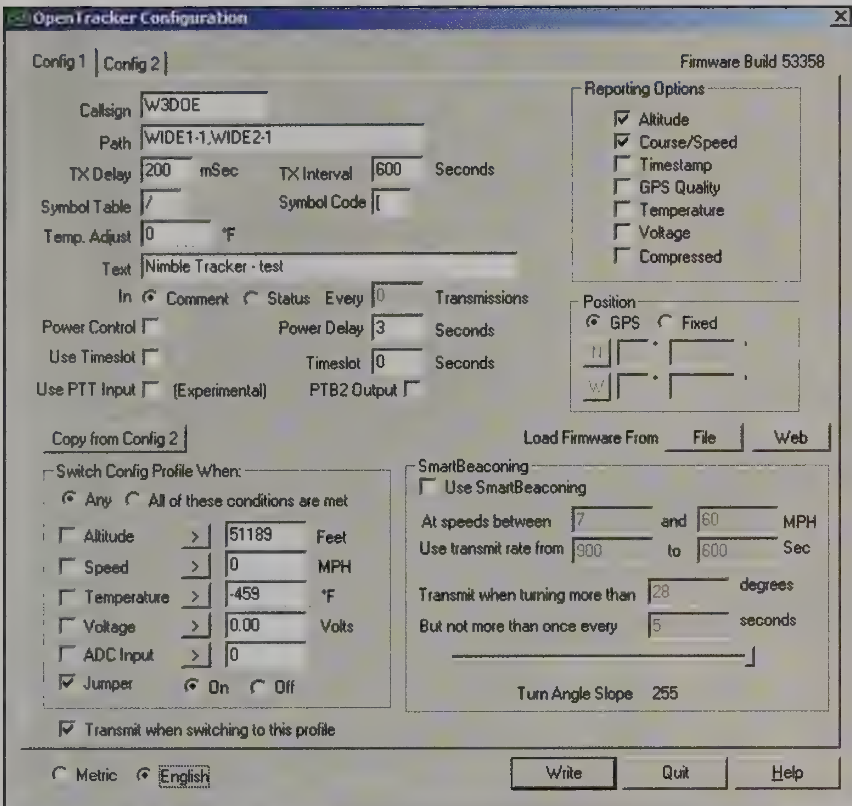

Photo 4. Screen shot of the OpenTracker configuration software.

Sport (http://www.icomamerica.com/products/amateur/t2h) shown in photo 2 fit the bill perfectly. Like the eTrex, used units in great condition can be picked up relatively inexpensively on auction or used-equipment sites. New units are not terribly expensive either, for that matter.

I did make one after-market change to the radio, though. Rather than use AA batteries, I purchased a 1700-mAh NiMH battery that was the same form factor as the included battery pack. Again, this is an elective option not required to build a successful tracker.

I built the cable shown in photo 2 to connect the radio to the output port of the TNC. While it works, I found during testing that it could be the source of a large problem: It picked up RF energy and directed it into the TNC, interfering with the TNC's ability to function. More about this later.

Photo 5. Modified container showing the installed homebrew serial cable.

The TNC

The TNC is the heart and soul of the tracker. It receives the position information from the GPS receiver and converts it into packet data the radio can transmit. In addition, the programming of the TNC determines how often the tracker will attempt to beacon, as well as what information is sent.

While there are a number of TNCs available to handle the various packet modes, I found two TNCs specifically designed for APRS use—the TinyTrak3 by Byonics (www.byonics.com/tinytrak) and the OpenTracker from N1VG (n1vg.net/opentracker). Both are extremely compact, have low power requirements, and are pin compatible so they can be interchanged if needed. Having used the TinyTrak3 in my first project, I chose the OpenTracker for this tracker. One consequence of this choice was having to find and modify a Serpac C6 case to hold the TNC board. The final result is shown in photo 3.

The next step was to program the TNC. This requires a Null Modem cable attached to a computer serial port. You probably will also need a female-to-female gender changer, since standard

Null Modem cables have a male connector on the end you need to connect to the TNC. Photo 4 shows a screen shot of the OpenTracker configuration software. It is here that you set your callsign, the digipath, what icon you want displayed on APRS software with the symbol table and code options, any secondary text transmitted as part of the beacon, and the time interval of the beacon or under what conditions it should beacon. For example, while this was set to beacon every 5 minutes, I could have enabled beaconing if my speed fell into a certain range or I turned greater than X degrees.

Of particular concern in programming the TNC is how a digipeater handles the tracker's traffic. While you want to ensure adequate repeating in your immediate area, you don't want to waste bandwidth and block others by requesting a large number of repeats. This is set by the PATH parameter in the software. Recommendations for this parameter have changed as APRS has grown and expanded over the years. Bob Bruninga's current recommendations are as follows:

• RELAY, WIDE, TRACE, TRACEn-N and SS are obsolete and are being phased out. Use at your own risk.

• Use WIDE2-2 for fixed stations. Use WIDE3-3 for fixed stations two hops or more from big cities. Use WIDE1-1,WIDE2-1 for two-hop mobiles in dense areas. Use WIDE1-1,WIDE2-2 for three-hop mobiles in remote rural areas. Use SS1-1,SSn-N for selected non-routine State or Section nets or when human operators are present for large area emergency needs.

This is only half of the TNC configuration. The TNC input and output levels must be set so it reads the radio correctly to (a) determine when someone else is beaconing at any given moment and (b) so it doesn't overmodulate the radio when beaconing. Accomplished by turning some set screws on the TNC board itself, I found the TinyTrak3 was significantly easier to tune through its software. It didn't take long to get the OpenTracker set up properly, though. It simply required changing to a non-APRS frequency, beaconing repeatedly, and listening on another radio to make sure the signal was clear. I followed this by connecting a radio to a computer with UI-View and "listening" to my beacon on this other frequency to make sure the packets were decipherable.

While I used the OpenTracker for a while, I must admit I eventually switched it out for a TinyTrak3 because of its enhanced programming capabilities and ease of tuning. This switch was driven purely by personal preference; the OpenTracker functioned well once it was set up.

The Enclosure

Believe it or not, this was the hardest part to find. I wanted to put the components in a basic plastic container that was just big enough to hold everything. I went to a number of large mass-market retailers, but they all carried the same type of merchandise. While it may have been great for storing food, the containers were all the wrong size for a tracker. Eventually I went to a local Container Store (www.containerstore.com), which carries a significantly broader range of shapes and sizes, to find what I was looking for.

Photo 5 shows the modified enclosure with a short, custom-made serial cable which connects to the GPS cable on one side and the TNC on the other. The other hole is large enough to permit either a rubber-duck antenna or an antenna extension cable to pass through. Both holes are covered by a rubber grommet so the plastic doesn't cut the cables. The serial cable has a wire tie on the inside to protect against disconnecting from the TNC if any tension is applied to the cable. Using an electric carving knife, I crafted a piece of 1-inch upholstery foam to fit into the container as well as cradle the radio and other components as shown in photo 6.

Photo 6. Radio, TNC, and cables neatly packed into the container, cushioned by a custom-cut piece of upholstery foam.

The Antenna

In my early field trials with this tracker I had problems which I quickly traced to the antenna I was using. In my original design I had envisioned using the tracker either with a better grade rubber duck directly attached to the radio for relatively compact deployment or using a BNC extension cable tethered to a 3-foot dowel rod out of my daypack so the antenna would be just above my head. I found one configuration worked while the other resulted in harmful interference within the TNC such that it

About the Author

Carlton Doe, W3DOE, is fairly new to amateur radio, having received his Technician license in 2004 and his Extra class license a year later. He is particularly interested in emergency communications and APRS technologies and has passed all three ARRL EmComm classes. His wife and kids, though, are still slowly adjusting to his new hobby.

Carlton lives in Flower Mound, TX, but may be evicted if the neighborhood association, or his wife, decides to throw a fit over the HF vertical he's mounted above his chimney. Regardless, he can be reached at <w3doe @arrl.net>. Oh, and for the record, he's not related to John Doe, so don't ask.—*N6CL*

didn't function properly. What puzzled me was it didn't matter where the antenna was. If connected to an extension cable I could lay the antenna right on top of the TNC and everything was fine. If, however, the antenna was directly attached to the radio and several inches from the TNC, there were problems.

Stephen Smith, WA8LMF, finally helped me understand that HTs with rubber ducks don't have a sufficient ground plane to function properly. When we use them for voice operation, our arms and bodys provide a type of ground plane, enabling the signal to radiate out. Within my tracker system that ground plane was missing, and the RF energy was following the interface cable from the radio into the TNC. With the extension cable attached, the shield of the cable, while not the greatest ground plane, was enough to divert the RF energy from passing into the TNC. To fix this, I could put RF chokes on each conductor of my cables, wrap the connector cables several times through a toroid or ferrite core, attach a proper ground plane to the antenna connector (such as a 19-inch piece of wire with an alligator clip), and continue to use my extension cable to connect the antenna or any combination of the aforementioned. Because I didn't want to remanufacture the radio-to-TNC cable and I didn't have the room inside the container for several cores, I opted for the extension and the additional ground wire. With those in place, I never had any more problems.

Summary and Parting Thoughts

This tracker has been a pleasure to use. It's small and light with just enough power to hit the closest digipeater. I can use the GPS receiver for general hiking and other activities, as opposed to just with the tracker, improving its value for the price I paid. All in all, I'm very pleased with the whole tracker.

So there you have it. To build an APRS tracker just get a radio, TNC, and GPS receiver and throw them in the same container in which you stored last week's leftover lasagna! Seriously, though, it's not too difficult to build a tracker if you do your homework up front. Determine what kind of tracker you want to build and how it will be used; evaluate and play off all the equipment options such as size, cost, power, weight, and so on; and then build to the plan. Start with something simple like this "nimble" model to learn the basics; you can re-use almost all the components should you later decide to build a bigger, more powerful tracker.

Above all, remember to have fun. The process of learning how is, in my opinion, more important than the final result. You'll miss-drill holes or cut wires too short. It's okay. Depending on what goes wrong, you may have to make drastic changes, but that's part of the adventure of this hobby. Enjoy it.

In part 2 I will cover the construction of a seriously over-engineered and over-geeked high-power tracker. In some respects it's how *not* to build a tracker, since I had no real design when I started and made things up as I went along. The final result represents four iterations of design and thinking changes after I'd begun construction—the ultimate in "scope creep" when building an APRS tracker.

Note

1. There are specific rules for how this should be done and they are covered later in the article.

A Hot Spot GPS Finder

Kenwood teams up with AvMap to give weak-signal operators precise driving instructions to that high, dirt-road site . . .

By Gordon West,* WB6NOA

On your upcoming hilltop VHF/UHF expedition, you won't necessarily need to bring a laptop along to see detailed color maps, along with APRS position-hit-callsigns all around you. A completely portable GPS bi-directional navigating receiver can do it all, with one simple cable between the receiver and a Kenwood D-7 handheld or D-700 mobile rig.

"I slip my D-7 into my vest pocket and run the cable to my portable GPS chart display, and I can walk anywhere and everywhere squawking my GPS position on APRS while also receiving and displaying APRS stations and their callsigns right on the GPS color-map display," comments Don Arnold, W6GPS, working with Kenwood Corporation and C-Map Group, which brings in the portable GPS charting receiver from its parent company in Italy.

Don Arnold, W6GPS, works AvMap on the test bench with a Kenwood D-7 handheld rig.

"For weak-signal operators, a combined GPS that also reads grid squares and sub grids, with bi-directional capability for receiving APRS positions of other weak-signal operators, has allowed many microwave groups to speed up dish pointing," adds Don, who is a recent convert to the exciting world of 10 GHz and above.

A few years ago, a handful of Garmin GPS receivers could also show APRS received callsigns, but the display was relatively small, plus it required additional keystrokes within submenus to display driving instructions to the distant callsign on the screen. With the new AvMap, a minimum number of keystrokes let you easily "ITT"—Intercept To Target.

It has been just one short year since AvMap introduced its first GPS color-map receiver specifically designed for the amateur radio market. A provided Y cable split out NMEA GPS 1200-baud position sentences and sent them to GPS TNC-enabled equipment such as Kenwood, plus ICOM and Alinco, radios with built-in (optional) TNCs. The first unit was called Geosat 2, and the hot GPS receiver actually was built right into the antenna unit. The split out of the data occurred before the GPS NMEA sentence reached the 12-volt $5^1/2$-inch display head.

Then came Geosat 2.5, putting the driving-instruction speaker in the back of the display unit, and switching the power plug over to a simple cigarette-lighter-plug assembly. Both the 2 and the 2.5 included a CD of the entire country, with 256 MB preloaded in a proprietary compact flash card with approximately six states loaded with TeleAtlas street-level mapping, plus over 4 million Point of Interest details, including hotels, restaurants, gas stations, schools, and campgrounds.

However, the Geosat 2 and 2.5 car navigators were *not* bi-directional, so you constantly needed to look at your radio to see where other APRS operators around you were. Also, ham operators regularly driving coast-to-coast routes did not like the hassle of having to upload new sections of the country on the proprietary 256-MB flash card.

In January of this year the 2.0s and 2.5s dried up in inventory at Ham Radio Outlet, the first ham radio dealer to bring in this unique amateur radio APRS device. They began taking on stock of the new Geosat 4, the platinum version fully loaded with all the United States on a 2-gigabyte secure digital memory card, and now including the bi-direction capability to send GPS data to your radio's TNC and also decode and display APRS position hits and callsigns on the 5-inch color thin-film transistor daylight viewable screen. It's portable, too, with lithium-ion rechargeable batteries on the inside. Great for geocaching!

However, before you let the kids have it to find that geocache out at the camp-

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Portable Mapping GPS for Geocaching

By Gordon West, WB6NOA

GPS receivers with built-in WAAS (Wide Area Augmentation System) capability can target an accurate position fix to the radius of a 10-foot circle 95 % of the time. The WAAS correction signal compensates your position fix based on area ground station differentials that are uploaded to a geosynchronous satellite and downloaded by a tiny WAAS-enabled GPS receiver.

Reference ground stations have been absolutely positioned down to centimeters and are constantly analyzed for where the GPS satellite fix "within their own high accuracy receiver" indicates they are. Variations in the ionosphere may show the ground station 15 feet in error due north. If this error settles in for a few hours, the ground station uplinks the information to let area WAAS-enabled GPS receivers self-compensate for this error, forcing the equipment to correct 15 feet to the south. This differential correction will undo the ionospheric error until the reference station detects its own position getting back to spot on. Conditions change relatively slowly in the ionosphere, affecting these errors and corrections, so the WAAS reception is applied every few minutes.

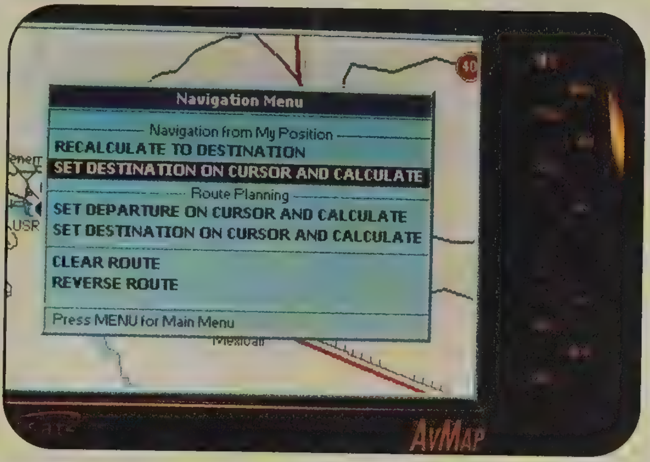
An older GPS without WAAS corrections typically is accurate to a 30-foot radius, and this is generally close enough to provide great highway navigation. Most highway GPS equipment will realize you're slightly off the straight road and automatically adjust for this error.

With spot-on accuracy with a common GPS with WAAS capability, an electronic game called Geocaching has swept the country. "More than 90,000 people have become interested in the sport since it was invented just a couple of years ago," says computer technician Jeff Atwood at the website <stubristol.com/geocaching.html>. "It's a game of high-tech hide and seek." Atwood is with MapTech, Inc., the developer of the popular topographic software for a laptop tied into GPS.

A Geocache enthusiast with a top-quality WAAS GPS handheld receiver will assemble a small watertight container of trinkets and a sign-in log book and hide it at a specific coordinate listed in degrees, minutes, *and fractions of a minute to 2 or 3 places*—not seconds, but fractions of a minute. Three digits after the decimal point will resolve accuracy down to 6 feet. Two digits after the final decimal point will resolve accuracy down to about 30 feet. One digit after the decimal point of a fraction of a minute will resolve a position fix to about 300 feet.

The cache of goodies might be in a small plastic kitchen container or maybe a cigar box, or maybe a tin from some kind of breath mints. The container needs to be large enough to hold a tiny pencil and sign-in log. Trinkets are included for trading.

This geocache (white tine) in the harbor was hidden on the channel marker "No Wake" sign. We needed a boat to get to it.



A new geocache coordinate is ready to follow!

The cache is hidden in a public place, and the GPS coordinates are checked and double checked to make sure they are as close as the equipment can provide. The coordinates are posted on numerous geocaching computer sites, and the fun begins. Sometimes hints are included to help zero in on the hidden target.

Now for *you* to find some secret caches hidden nearby, get started by bringing up the website <www.geocaching.com>. Move around the site to get as much information about this fun sport as you can, and then bring in some of the latitude and longitudes of hidden "treasures" near you.

While each portable GPS receiver has its own set of button pushes to input latitude and longitude, the most exciting portable GPS equipment is the unit that also has local maps. We used the Geosat 4 with its color screen and built-in battery supply and GPS antenna system. To use this unit, first press the FIND button, then select LAT/LON, next insert the latitude and longitude coordinates, press MENU, and set the final destination to find.

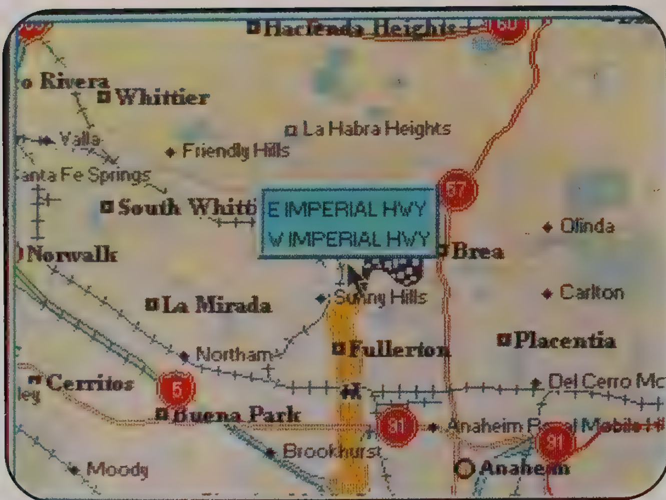
You can either beeline it directly to the hidden cache, or look over the map and decide which way will get you there without dropping off a cliff or fording a raging river. All this time your GPS mapping equipment is also showing the path that you traveled to get to the hidden location. Some will even calculate how long it's going to take to get there, too!

When you zero in on the GPS created mark, double check that the GPS readout agrees with the hidden cache readout, and then double check again that both readouts agree in either fractions of a minute (preferred) or seconds. Keep in mind that .5 of a minute equals 30 seconds.

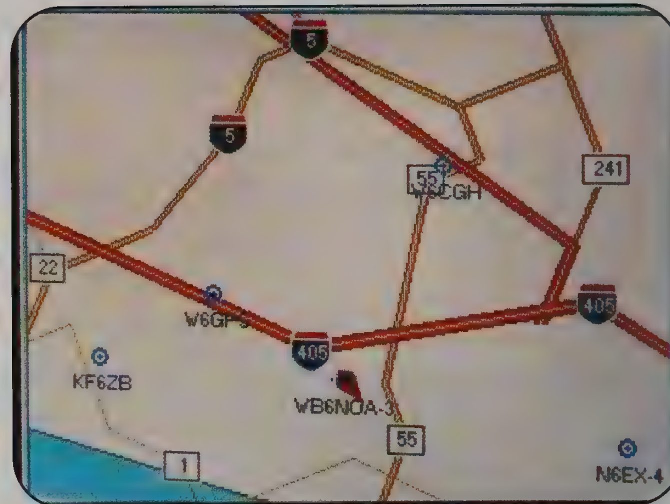
Now start looking around and over and under. The geocache is not going to be left sitting out in the open, but rather will be protected from someone not in the know accidentally discovering it and taking it home. The local geocache that we found here in southern California was right in the middle of a pedestrian foot bridge over a river. It wasn't until we got down on our hands and knees and looked under the planks that we discovered the tin box.

Geocaching helps refine your GPS skills. For the emergency search-and-rescue teams, latitude and longitude distress calls are uplinked via PLBs (Personal Locator Beacons) on a 406-MHz data burst. Maybe your emergency search-and-rescue group is dispatched to a specific latitude/longitude. If you are active with geocaching, you will have the latitude and longitude programmed within seconds, a mark created, and a clear readout on how to get to the distant target.

Geocaching is more than just a game. As more PLBs are turned on in an emergency, the skill of locating latitude/longitude will become a lifesaving technique for everyone with a tiny GPS receiver.



The AvMap daylight-viewable screen features bright, bold graphics.



Callsigns pop up on the screen of the new AvMap G4T hooked up to the Kenwood D-7.

ground, consider all you can see on the color daylight-visible screen during the next weak-signal weekend:

- Mapping down to many dirt-road levels
- Fix (your position) latitude/longitude
- Cursor lat/lon anywhere you choose
- Maidenhead grid square to sub-grid readouts
- Distance to cursor target
- Driving instructions to chosen distant APRS station

All this is just on the first mapping screen, with little boxes off to the right. A few button pushes get you into multiple windows to calculate magnetic or true bearings to other microwave stations, either choosing the APRS ID or using the cursor to match the stated latitude and longitude.

If someone indicates he or she is on the tip top of Signal Peak, you might even look up that information out of the millions of TeleAtlas POI information systems and tell your AvMap to calculate the magnetic path bearing.

Also, if it looks as if you may need to hike in to that secret high spot, the AvMap can unplug from 12 volts DC and work completely portable for up to an hour, hooked into your Kenwood D-7, offering GPS data for Kenwood APRS transmit and on-screen APRS fixes of those stations all around you.

More Technical Info . . .

The Geosat 4 incorporates the 12-channel receiver *within* the display body, along with a display body patch antenna. The GPS receiver also incorporates a wide-area augmentation system (WAAS) for spot-on position accuracy, even showing on which side of the street you are parked. Although there is a jack for an outside-vehicle GPS antenna, I have yet to find a car, RV, or motorhome with which I can't get enough signal on the inside!

DC power input may be anything from 10 volts DC to 36 volts DC. External power input automatically safe-charges the built-in lithium-ion battery pack. The battery pack will continuously run the equipment anywhere from 30 minutes to 2 hours, depending on how you have set the TFT display backlight. The LCD TFT ultra-bright 5-inch color screen has the resolution of 320 × 240 pixels, and has an automatic brightness control as well. It will go into an amazing "blackout" lighting in the dead of night, still highly visible, but easy on the eyes.

Author Gordo, WB6NOA, gets dish-aiming information from the AvMap G4T.

The Geosat 4 also includes a PC interface for software updates, as well as the capability to upload alternate mapping areas such as Alaska or over 20 countries covered by TeleAtlas in Europe. Included with each Geosat 4 receiver is a USB cable along with a DVD with Canadian cartography.

You can also receive free software updates from <www.AvMap.it>.

Each time you wish to home in on an APRS hit, it becomes a "mark," with 1000 mark points capability. With a couple of key strokes you can then calculate the best route to actually drive

to that other station, choosing either the shortest route or the calculated fastest route. Also, when you finally finish up with your mountain topping, a single push of the drive-me-home button automatically calculates the voice and visual instructions to your home QTH.

Included with the Geosat 4 is an interconnect cable for the popular Kenwood D-7 or D-700 transceiver with built-in TNC. The silver three-pole plug goes into the Kenwood radio GPS input/output socket. On the Kenwood D-700, make absolutely sure you spot the right hole before plugging in the cable. If you're not careful, you could accidentally push the small plug into the hole for RESET, and just one push will completely undo anything and everything in your Kenwood D-700 memory. Get the right hole!

The other end of the cable features a gold four-pole plug, and it goes into the "TMC" (Traffic Management Channel) port on the back of the Geosat 4. This is the same jack that will accept a "Y" cable adapter if you decide to sign up for monthly traffic-management reception—an over-the-air subscription service that turns your little GPS receiver into a smart freeway or expressway monitor, showing you up-to-date traffic conditions all around you.

On your Kenwood D-7 or D-700 radio, you will need to get into the APRS menus and add your callsign, select NMEA 96 data rate 9-digit NMEA information, and select your packet path, such as wide 1-1, wide 2-2. If your Kenwood radio has any packet path "relay," "relay, wide" is no longer used.

Many duplicate packets are generated by relay wide by these paths and cause collisions and lost packets. Go for wide 1-1, wide 2-1 recommended for mobiles for two hops; or wide 1-1, wide 2-2 for mobiles for three hops. *Avoid* relay! On some very early Kenwood D-7 handhelds, you may notice that your radio goes "beep" every few seconds, indicating the proper flow of NMEA data between both units. You can turn the volume down to minimize the "beep" driving you crazy, or you can send your very early Kenwood D-7 back to a Kenwood service center for an upgrade. Newer Kenwood D-7A handhelds all have the new upgrade program and won't "beep" at you every few seconds, except when you have selected "Beep" from a menu.

During recent testing, I found the AvMAp Geosat 4 quiet as a mouse with regard to EMI leaks. There was not a sign of the display or receiver heard on 6 and 2 meters SSB, 432 and 1296 MHz SSB, and higher. At 10 and 24 GHz, there was no RFI coming from the equipment.

The Geosat 4 can also take video input from gear, such as DVD, backup camera, and SSTV output from an ICOM R-3. There is even an optional TV tuner that lets you tune channel 3 and channel 8 in case you wish to decode ATV signals from any PC Electronics downconverter.

Best of all, for the weak-signal operator, the Geosat 4 is uncomplicated. Stick it on your front windshield with the supplied suction-cup bracket, add 12 volts to recharge the internal batteries and to power it up as you head for the high site, and let the canned voice in your choice of multiple languages steer you to your secret spot. Even in the bright sunlight the color screen stays visible!

If you have technical questions about the Geosat, send an e-mail to: <info@ Geosat.US>. If you want to look at some of the sample screen images, go to <www.Geosat.US>. To receive reviews from a Yahoo group, go <http://groups. yahoo.com/ AvMapg4t/>. And if you already own a Kenwood D-7 or D-700, it is truly plug and play! ■

By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

Remembering Two T-Hunting Comrades

Carl Jung, the famous Swiss psychologist, wrote: "The meeting of two personalities is like the contact of two chemical substances. If there is any reaction, both are transformed."

Ham radio brings personalities together. On the air, at meetings, flea markets, Field Day, and many other events, we become acquainted with people with whom we share an interest in radio communications. Lasting friendships are created and lives are changed.

Nowhere is this more evident than among aficionados of radio direction-finding contests, both mobile and on foot. I often have written about the camaraderie that builds among hams as they engage in friendly competition to see who can assemble the most effective radio direction-finding (RDF) systems, who has the best "foxhunting" skills, and who can find the cleverest transmitter hiding sites to keep the "hounds" at bay.

Although they always welcome newcomers, the mobile T-hunters of southern California are an unorganized but close-knit community of strong personalities who play hard at their weekend sport. They also work hard when called upon to solve RF interference problems. On Memorial Day weekend, they were hit by the loss of two of their finest. As reported in the amateur radio press,[1] Mike Obermeier, K6SNE, and David Gordon-Ross, N6IDF, lost their lives when Mike's Jeep went off a mountain road near Lake Isabella in Kern County, California on May 27. It was the first serious accident in over three decades of mobile transmitter hunts in the Los Angeles area.

Southern California T-hunters were stunned. For weeks they had seen photos that Mike had e-mailed about the reworking of his Jeep to make it perfect for on-road and off-road use. He could hardly wait to take it out on one of our "All-Day" 2-meter hunts, which usually last for a full weekend and involve hundreds of miles of travel to find several well-hidden transmitters in the mountains and deserts. Even though he was a paraplegic, Mike had done his own shop work, mostly by himself.

K6SNE was one of the most active ARRL Official Observers in southern California. Thanks to the efforts of Mike and other T-hunters, there is now an unprecedented level of cooperation between ARRL OOs and the Los Angeles area FCC office in Cerritos. Mike put the finger on numerous repeater jammers and non-identifying troublemakers, including the infamous Jack Gerritsen.

David and Mike were always eager to use their RDF skills to find the sources of spurious signals and malicious interference. The problems did not have to be on a ham band; I told you about K6SNE's adventure on a banana boat in the Los Angeles harbor in my "Homing In" column for the Fall 2004 issue. He didn't hesitate to become aggressive when the ship's Russian crew members were indifferent to the likelihood that their radio gear might be making the mariners' international distress and safety channel unusable for many miles.

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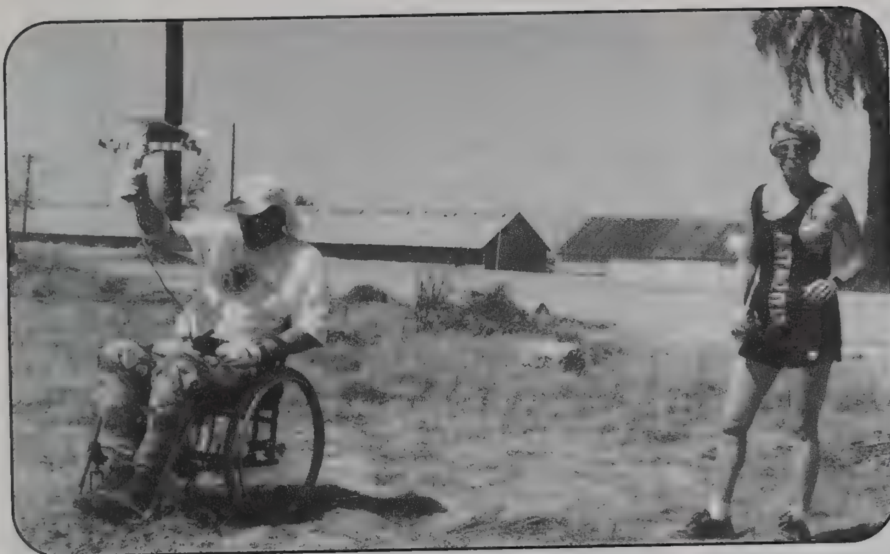
At a recent club meeting, Catherine Deaton, the District Director of FCC's Los Angeles area office, was very animated when talking about the excellent cooperation between her agency and ARRL Official Observers in solving interference problems, both inadvertent and malicious. Ms. Deaton was in the large crowd that paid respects to K6SNE at his graveside service. (Photo by Joe Moell. KØOV)

It takes that sort of perseverance and self-confidence to find well-hidden transmitters in the mountains and deserts of California and western states. N6IDF and K6SNE were fearless, but they weren't foolhardy. Contrary to some uninformed posts on internet ham radio message boards, they were doing nothing more dangerous than traveling a narrow dirt road. Mike had two decades of experience driving with hand controls, but something went wrong this time.

There are two opportunities to honor Mike and Dave. The Michael Obermeier Memorial TV/Video Scholarship has been established by Santa Ana College, where Mike was an instructor. A savings account has been set up for the benefit of David's one-year-old son. The latest information on these memorials[2] is on my website.

Rolling Toward the Fox

K6SNE had been active in outdoor sports until an accident put him into a wheelchair on his nineteenth birthday. Thus, it's not surprising that on-foot transmitter hunting appealed to him almost as much as mobile RDF. When international-rules



In 1995, Mike Obermeier, then KD6SNE, was the first ham in the USA, and perhaps in the world, to participate in an ARDF event from a wheelchair. At right is Christie Edinger, KØIU, his extender. (Photo by KØOV)

radio-orienteering first came to southern California during the mid 1990s, Mike wanted to join in. That led to a pioneering experiment with the concept of "extenders" for competitors with disabilities.[3]

For the 1995 ARRL Southwestern Division Convention's on-foot hunt, the site wasn't suitable for special courses to accommodate solo blind or wheelchair hunters. Instead, K6SNE (then KD6SNE), and Dennis Schwendtner, WB6OBB, a sightless ham from Santa Barbara, were each accompanied on the regular course by a physically fit person who went into inaccessible places at the command of Mike and acted as eyes for Dennis.

The extenders weren't permitted to do any RDF; that was to be done only by K6SNE and WB6OBB. The extenders could only be used to overcome the limitations of their disabilities. Mike's helper went into the brush or dirt to search, without RDF equipment, at his direction. Dennis' extender described to him the terrain features and the presence of other hunters in the area in which he was searching.

Nobody had more fun at this convention foxhunt than Mike, Dennis, and their extenders. Neither won a prize, but they successfully found transmitters and received certificates of merit. It was a great example of inclusion and mainstreaming, two buzzwords that are popular with educators nowadays.

The concept of extenders for full-size ARDF courses has not yet caught on nationwide, but wheelchair-friendly on-foot transmitter hunts are becoming more common. In "Homing In" for the Spring 2005 issue of *CQ-VHF*, I wrote about special RDF events for students at Courage Handi-Ham Radio Camp in Malibu, California last year.

Another example is the Sequim and Port Angeles event that will take place on August 26, 2006 on the North Olympic Peninsula of Washington state.[4] According to Neil Robin, WA7NBF, there will be at least two transmitters to find in a seacoast park. One of them will run 100 milliwatts on 146.565 MHz and will be wheelchair accessible. Maps will be provided, as well as a picnic lunch.

Stray Video in Colorado

Nobody liked to tell or listen to a good transmitter hunting tale more than N6IDF and K6SNE, especially if the story was about the solution of a real interference problem. They would have enjoyed this story, which took place in March. Dan Meyer, NØPUF, of Englewood, Colorado wrote that it started when people were having problems connecting to the packet cluster on 145.05 MHz at his house.

"Our network in the Denver metro area is used almost exclusively for emergency communications and related training," he wrote, "so we needed to get it fixed promptly. I noticed that there was an S5 to S9 signal on the frequency that was locking out people's packet TNCs at certain times of the day. The modulation sounded somewhat like a 60-Hz hum. After a few days, I found a pattern to the noise; it seemed to be more prevalent during the early morning and late evening."

Dan continued, "To eliminate the possibility of the source being in my own house, I disconnected everything from the mains and ran several radios on batteries. The noise continued. I drove around my neighborhood and heard very little if anything. Next I called Bob Schellhorn, NØTI, to see if he heard it at his location, 20 miles north of mine. Sure enough, it was stronger there. Bob said it sounded to him like TV sync.

"I sent out packet, voice, and e-mail messages asking people to send reports of their location, signal strength, and bearing to the source. By plotting the many responses, it appeared to be in the north, probably around the Broomfield or Boulder area. As it turns out, some of the bearings were inaccurate, but at least we had some idea as to where to look.

"All of this took about a week's time. The following Saturday after our regular club breakfast, I set out to find the noise along with Chris Krengel, KBØYRZ, Ben Baker, KBØUBZ, and Ann Trudeau, KAØZFI. As I traveled along US 36, the signal became very strong. Chris stopped at 23rd Street and I-25 to provide a cross bearing, which narrowed the search area quite a bit. Then the signal went off, or so it seemed. Bob did some tuning and found it at 145.120 MHz. Hmmm, that might also explain the interference that some voice repeaters were having.

"Our three vehicles converged on the hot area, but due to numerous metal buildings, towers, fences, and storage tanks, we chased our tails for about an hour. Every time I moved ten yards, the bearing seemed to change 180 degrees.

"After some discussion, the four of us concluded that the source had to be near the Union Pacific rail yard. There were several towers on the property with lots of antennas on each. As we were looking around, a UPRR employee stopped us and asked us what we were doing. Although we were not on the property, he told us not to proceed any closer. Not wanting to face federal trespassing charges, we did as we were asked."

By driving carefully along the edges of the rail yard, the group finally identified the offending tower. Ben took pictures of the area and made a map of the location. They obtained a phone number of the railroad communications liaison from the employee on site.

Benjie Campbell, WØCBH, picks up the story from there: "On Monday morning, I contacted the supervisor of the

Is it in there? Scouts are learning to search for hidden transmitters at JOTA 2005 with instructor Marvin Johnston, KE6HTS. (Photo by KØOV)

Several of the practice transmitters at SBARC JOTA were wheelchair-friendly. (Photo by April Moell, WA6OPS)

Union Pacific Signal Department in the Denver area and explained what we had found. He asked for a time that we could come out and show him what we had discovered. Next day, I received an email from Dennis Leesley, KKØQ, a UPRR employee who had been assigned to the job. He had taken some equipment out and found a buzzing signal coming from the tower. It did have a camera on it, but it belonged to the Burlington Northern and Santa Fe railroad, not UPRR.

Dennis Schwendtner, WB6OBB, and his extender, Linda Reagan, now KF6MOB, found several transmitters at Hamcon/ Foxhunt 1995. (Photo by KØOV)

"Dennis knew some people at BNSF," WØCBH continued. "He called them and together they went to the site and discovered that a wideband amplifier had been inserted in the circuit for the BNSF video camera. They replaced the amplifier and the noise disappeared."

Congratulations! This was another successful find for these Denver area transmitter hunters, who get lots of RDF practice on high-altitude balloon flights by the Edge Of Space Science organization. Unlike southern California mobile T-hunters, whose motto is usually "every team for itself," the EOSS recovery group has refined the art of cooperation among hunt teams to quickly coordinate the return of valuable payloads, which often land over 100 miles from the launch site. A visit to the EOSS website[5] will give you volumes of information on RDF for balloon recovery, including map overlays and a spreadsheet for automatic triangulation by Paul Ternlund, WB3JZV.[6]

Get Ready for JOTA

As this issue arrives in readers' hands, hams and Scout leaders are planning the 49th annual Jamboree On The Air (JOTA), to take place October 21–22, 2006. All over the country, Scouts will experience the thrill of talking with other Scouts via amateur radio. They will participate in other ham activities such as building electronics, using specialty modes, and in some places, they will hunt hidden transmitters.

Last year I had the privilege of helping members of the Santa Barbara Amateur Radio Club (SBARC) put on an ambitious JOTA campout weekend for seven Scout troops at the Sedgwick Reserve. This 6000-acre wilderness area in the Santa Ynez Valley of California is owned by the University of California at Santa Barbara and is the site of frequent "digs" by UCSB archeologists such as Michael Glassow, KK6NP, and Anabel Ford, KC6GWA.

In charge of the 2005 SBARC JOTA was Darryl Widman, KF6DI, a former Scoutmaster and Scout Commissioner who

CQ's 6 Meter and Satellite WAZ Awards

(As of July 1, 2006)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones needed to have all 40 confirmed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23,24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	2,16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25,28,30,31,32
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	1,10,18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,10,12,18,19,23,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27.28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23.28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	KØSQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IKØPEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28
72	K4MQG	17,18,19,21,22,23,24,25,26,28,29,30,34,39
73	JF6EZY	2,4,5,6,9,19,34,35,36,40
74	VE1YX	17,18,19,23,24,26,28,29,30,34
75	OK1VBN	1,2,3,6,7,10,12,18,19,22,23,24,32,34
76	UT7QF	1,2,3,6,10,12,13,19,24,26,30,31
77	K5NA	16,17,18,19,21,22,23,24,26,28,29,33,37,39
78	I4EAT	1,2,6,10,18,19,23,32
79	W3BTX	17,18,19,22,23,26,34,37,38

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40
23	VR2XMT	01 May 06	2,5,8,9,10,11,12,13,23,34,40

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. In 2001 we "lowered the bar" from the original 40 zone requirement to encourage participation in this very difficult award. A Satellite WAZ certificate will indicate the number of zones that are confirmed when the applicant first applies for the award.

Endorsement stickers are not offered for this award. However, an embossed, gold seal will be issued to you when you finally confirm that last zone.

Rules and applications for the WAZ program may be obtained by sending a large SAE with two units of postage or an address label and $1.00 to the WAZ Award Manager: Floyd Gerald, N5FG, 17 Green Hollow Rd., Wiggins, MS 39577. The processing fee for all CQ awards is $6.00 for subscribers (please include your most recent *CQ* or *CQ VHF* mailing label or a copy) and $12.00 for nonsubscribers. Please make all checks payable to Floyd Gerald. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. N5FG may also be reached via e-mail: <n5fg@cq-amateur-radio.com>.

**17 Green Hollow Rd., Wiggins, MS 39577; e-mail: <n5fg@cq-amateur-radio.com>*

By Rich Arland,* K7SZ

BEGINNER'S GUIDE

All you need to know but were afraid to ask . . .

Fun with VHF—MilCom Equipment

Sometimes we tend to forget that amateur radio is a hobby, something to have fun with. All too often we collectively take ourselves way too seriously. With this in mind, this column is dedicated to having some fun with VHF. Along with the fun we will hopefully entice some of you to try something a little different in the radio hobby—a road less traveled, if you will, but filled with rewards nonetheless.

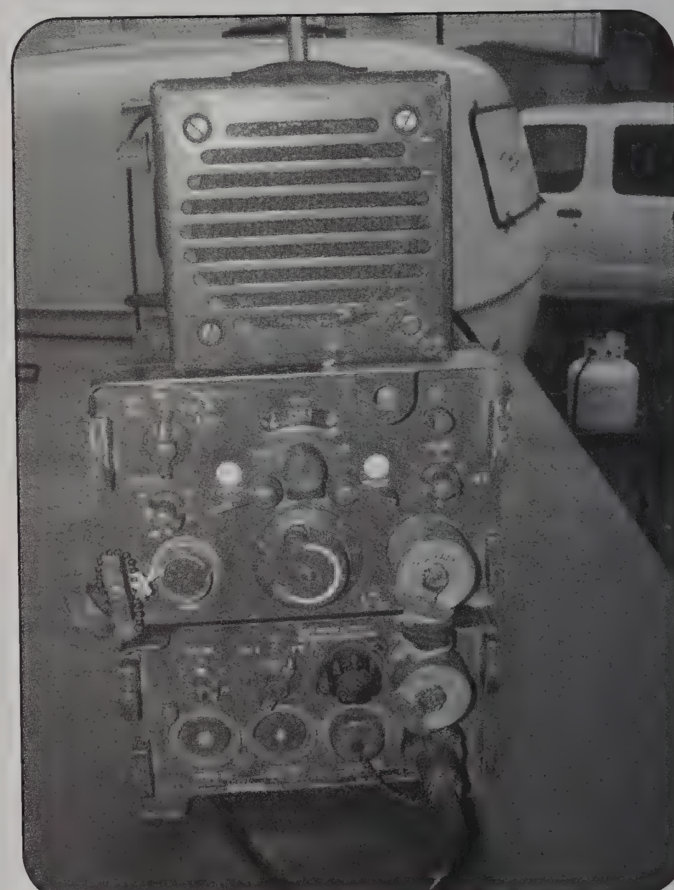
If you have been reading this column since the beginning, you will remember that your author (that would be me) has an extensive military background. Having spent 20 years in the U.S. Air Force in (what else) Comm Command, I have had a lot of experience with military communications (MilCom) equipment. Only within the last several years, though, has the bug bitten to start obtaining some of this classic military radio gear and use it on the air.

Now I know what you're thinking: Military gear smells funny, is a nasty shade of green, is big and heavy, takes funny voltages and weird connectors, and isn't very easy to work on when things go wrong. Well, the vacuum-tube and solid-state military equipment is basically no different than any other commercial vacuum-tube and solid-state gear as far as voltages are concerned. Of course, how the military power supplies develop those voltages can be somewhat convoluted, depending upon dynamotors (huh?) and vibrator power supplies (say *what*!)

Well, the good news is that these power supplies are readily available on the used market, and since they are extremely rugged and relatively easy to repair, seldom will you have to do any troubleshooting in order to make things work. As far as connectors are concerned, they are also available from various sources at reasonable cost. Concerning maintenance, a little known fact among non-military folks is that the Technical Manuals (TMs) and Technical Orders (TOs) are written on about a sixth-grade level and are very detailed, including extensive troubleshooting information. OK, the smell: That is an anti-fungal shellac that is sprayed on the older military gear (WW II through Viet Nam era equipment) and many of us "Green Radio Guys" actually love the smell of the gear! Hey, one snort of that stuff and you know you have your hands on a piece of "real" radio equipment! As for big and heavy, yes, some of it is, but that is due to the stringent engineering that is needed to meet military specifications (mil spec) and survive in combat. In short, you can't really go wrong buying and using MilCom gear if you have the TM/TO for each particular piece of gear you own. There are many sources of TMs and TOs, so finding the right tech info is a no-brainer.

For the last 41 years I have been a proponent of QRP, low-power (5 watts and under), ham radio. Believe it or not, the U.S. military is also a big proponent of QRP and has been using it since WW II. The most familiar squad radio from the WW II era is the BC-611 handheld radio designed by Galvin Manufacturing in 1940. Galvin Mfg. later became Motorola, so the lineage of the BC-611 is pure thoroughbred all the way!

Often misidentified as a "walkie-talkie," the BC-611 was about the same size as a quart milk carton with a 39-inch pull-up whip antenna (that turned on the radio when it was extend-



This is the venerable RT-70 transmitter/receiver (middle) coupled to its 24-volt power supply/audio amplifier, the AM-65. The loudspeaker atop the RT-70 is an LS-166, which is common among most MilCom units of this vintage. This set was used from the Korean War well past the Viet Nam era by the U.S. military in jeeps, trucks, command posts, and about anywhere tactical VHF FM voice communications was required. The RT-70 is connected to the AM-65 by spring clips on the sides of the case. Power to the AM-65 is accomplished by a cable in the lower left socket. The voltages necessary to run the RT-70 along with audio transmit and receive are coupled between the two units via a "dog-bone" connector on the right side of the radio/PSU. This unit weighs in at arond 35 pounds.

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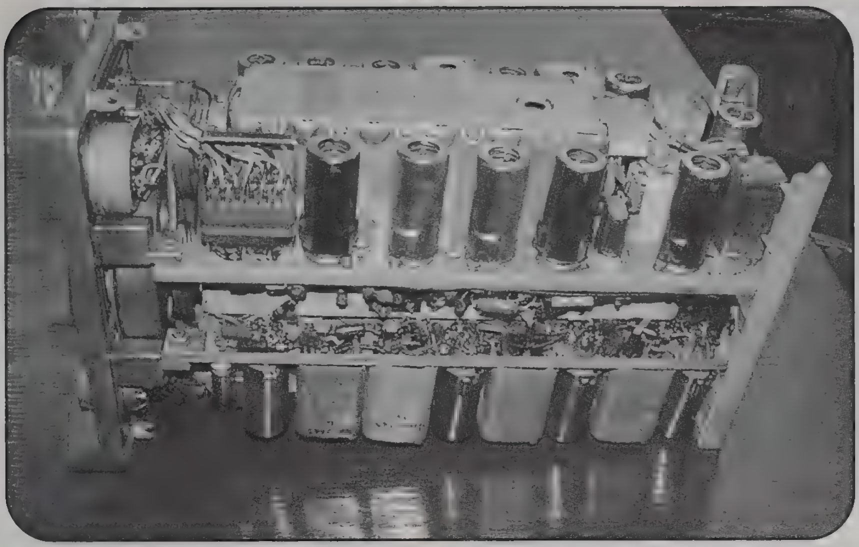
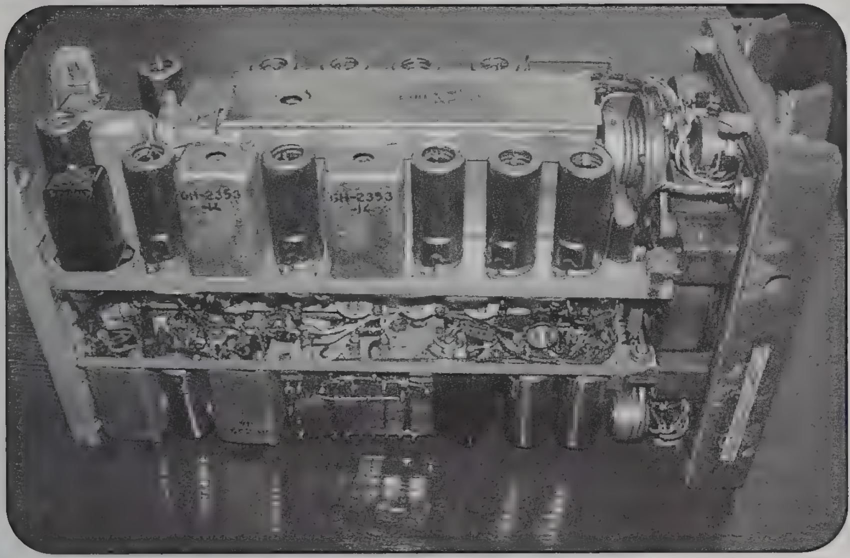




Here are shots of the top and bottom of the inside of the RT-70. As you can see, this radio set was built to last. Rugged? You have no idea!

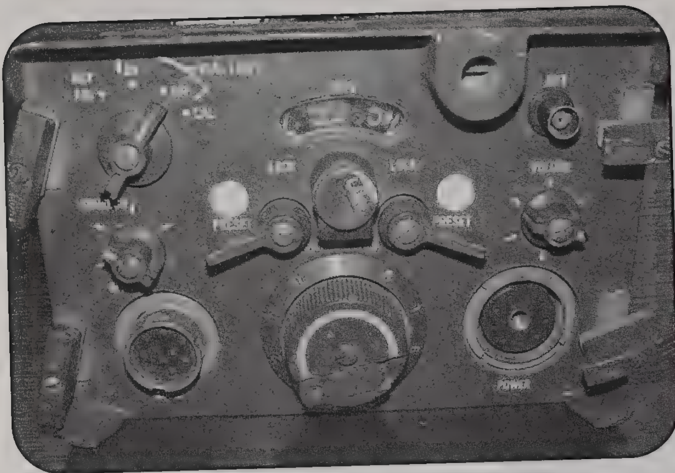
ed to full length). With a short whip one would think that the BC-611 was a VHF radio. Not so. The BC-611 was an amplitude-modulated, 80-meter radio that put out somewhere between 100 and 300 milliwatts! Most of them were rocked up on 3885 kHz at the depot and that is where they stayed for the duration.

The Army quickly found out that 80 meters was not the most effective frequency on which to conduct battlefield operations. They moved to low-band VHF (30–76 MHz) during WW II using wideband FM and carried on the tradition through the Viet Nam War.

From the end of WW II onward, the move to low-band VHF/wideband FM was not only a wise choice, it was to become a boon for frugal ham radio operators needing well-made VHF gear at reasonable cost. You have to remember that military comm gear was state of the art or slightly beyond during the time the gear was designed and fielded. Not only that, MilCom gear is unbelievably rugged. It has to be, especially when you are bouncing it all over the place while getting shot at! Therefore, especially if you were on a strict budget, procuring some surplus MilCom VHF gear, restoring it, and using it was not all that outlandish as ideas go. That is still the case today.

What's Out There

Now that we have broken the ice with a short history lesson, let's see what is actually out there that you might want to



Here is a better shot of my other RT-70, which cosmetically is in better shape than the one mounted to the AM-65. Cosmetics matter very little in the grand scheme of things. Often the more beat up the rig, the better it works! Don't ask; I don't understand it either!

obtain and use. Since this is a VHF magazine, we will dispense with the run-of-the-mill HF gear (of which there is a multitude of rigs to be had) and concentrate on some of the more common low-band VHF gear available on the used market.

Since ham radio is a technical hobby, we will endeavor to learn a little bit along the way. One of the really nice things about restoring and using MilCom gear, especially some of the older gear that uses vacuum tubes or hybrid (combination solid-state and vacuum tubes) designs, is the historical significance of the equipment itself. For instance, the AN/PRC-6 was designed around the Korean War timeframe. It was the ultimate in vacuum-tube technology of the 1950s, using the small "pencil tubes" which had no pins like normal vacuum tubes, but instead had wires extending from the glass envelope. These leads were soldered into the circuit, negating the need for sockets, which often proved unreliable under the extremes of combat. One additional benefit of not using tube sockets was miniaturization. No sockets meant that the overall package could be made much smaller physically. The PRC-6 had a long run and was used by all NATO nations and the Israeli military. As a matter of fact, the most common PRC-6s currently found on the used market are ones that were released from the Israeli army, complete with Israeli markings! They are a neat piece of history, and you can make them work with ten 9-volt transistor batteries connected in series for the plate voltage supply, three AA cells for the 4.5-volt bias supply, and two C or D cells for the filament supply. All of these batteries fit inside the PRC-6 case and will supply the necessary voltages to put the rig on the air.

Speaking of "on the air," 51.0 MHz is the 6-meter defacto squad radio frequency for ham radio operators. Of course, the PRC-6 is a crystal-controlled radio set, but the crystals are readily available on the internet at very reasonable cost. As initially designed, the PRC-6 was a single-channel radio set. However, leave it to the Germans: They produced a six-channel version that is virtually the same size and uses the same case. Sometimes these PRC-6 clones can be found on MilCom radio lists and auction sites on the internet.

Another Korean War era VHF radio set that is quite common on the used market is the PRC-10. It is one of a series of radio sets that included the PRC-8, 9, 10, and 28. All are wideband

The AN/PRC-6 Walkie-Talkie is a single-channel, 250-milliwatt output, low-band VHF (44–55.4 MHz), wideband FM transceiver. This unit uses "pencil tubes" and was pushing the state-of-the-art in the 1950s for compact design. It weighs 3.5 pounds without batteries. Since you can no longer obtain military batteries for these radios, you will have to make your own using 9-volt transistor-radio batteries (about ten in series for 90 volts B+), three AA cells for bias supply, and two C or D cells in parallel for tube filaments. The antenna is a flexible tape antenna about 2 feet long. Typical range is about 1/2 to 1 mile depending upon terrain.

Always one to lend a helping hand, my 5-year-old grandson, K.C., is posing with Pop-Pop's PRC-6 walkie. This photo gives some indication of size. If there were a full set of batteries in this radio, K.C. would have his hands full just trying to pick it up!

FM radio sets that cover various frequencies in the low-band spectrum between 27 and 54.0 MHz.

The PRC-10 is the one we want for 6 meters, and since it is fully tunable from 38 to 54 MHz, you can select any number of 6-meter frequencies. However, don't forget, 51.0 MHz is the place where all the MilCom aficionados congregate. The PRC-10 radio set is a true pack-set or man-pack radio. It is designed to be carried on the back of a soldier (the RTO—Radio Telephone Operator) and has two different length antennas—a 38-inch tape whip and a 10-foot 1-inch tubular whip. The radio weighs in at 11 pounds without battery, 20-plus pounds with battery and all accessories (H-33 handset, LS-166 speaker, H-63 headset/boom mic, and/or GSA-6 Chest Set).

The power output of the PRC-10 is about 1 watt, and, as with the PRC-6, you will have to build your own battery pack, which is easily done using D, AA, and 9-volt transistor-radio batter-

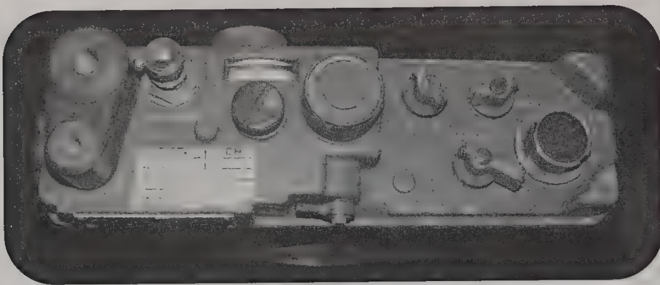
ies, or 45-volt batteries available on the internet and from specialty radio stores such as Antique Electronic Supply (www.tubesandmore.com) in Tempe, Arizona. A search on the internet will also yield several sources of DC-to-DC converters that are available commercially. These converters will take a 6- or 12-volt sealed lead-acid (gel-cell) battery and present the proper operating voltages for the vacuum-tube MilCom gear at the output. To date I have seen DC-to-DC converters for the PRC-6, PRC-10, BC-611, PRC-25 & 77, along with the AN/GRC-9 (HF CW/AM transmitter/receiver). Although initially expensive, these are probably the way to go in the long run, since making battery packs can become quite time consuming and bothersome.

Costs are reasonable for the PRC-6 and PRC-10s; plan on spending between $50 and $90 for the former and around $35 to $75 for the latter, depending upon cosmetic condition, accessories, etc. Recently I procured a pair of PRC-10s, in working condition, with two sets of pack hardware, two H-33 handsets, and two each of the long and short antennas for a grand total of $95, which included shipping from Louisiana. Not a bad deal at all. Internet auctions lately have had an over abundance of the AM-598 power supply/audio amplifier which mates with this radio set to provide vehicle or command-post (fixed station) operations. Prices for these accessories have been running around $50–60 without shipping.

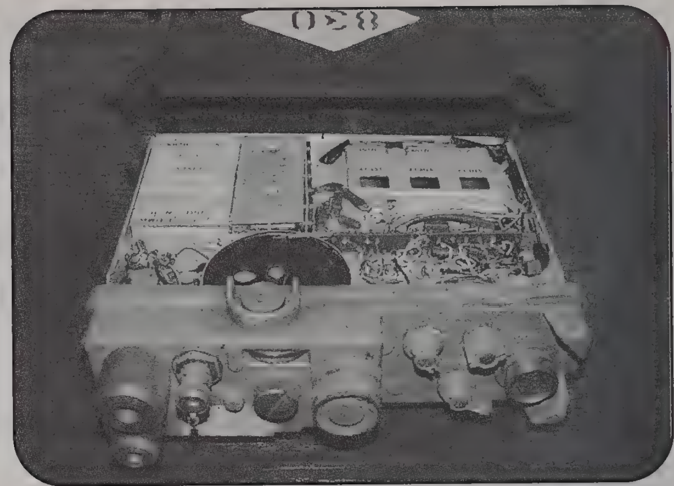
One word of caution: Most of the military gear we will be looking at uses power supplies that take a 24-volt DC input, since that is what most military vehicles have for internal power. The easiest way to provide 24 VDC for your power supplies is to connect two 12-volt deep-cycle batteries in series and use them to power the power supply. Ultimately, the best solution would be to build a 10- to 15-amp 24-VDC supply that uses AC mains on the input. But to initially get the gear on the air, there is nothing wrong with strapping a couple of 12-volt storage or deep-cycle batteries in series to get the necessary 24 volts to run the radio gear.

Another Korean War/Viet Nam War classic transceiver that is seeing plenty of use on 6 meters is the RT-70. These radio sets were designed for vehicular mounting and for use as fixed-station assets in command posts. The AM-65 power supply/audio amplifier powers the radio set and provides audio inputs and outputs and will drive a speaker. The RT-70 is my kind of radio. It is about 7.5" × 5" × 13", weighs about 15 pounds, and covers 47 to 58.4 MHz using wideband FM. Made like a tank, these rigs are great starter radios for the newbie in MilCom radio. The transceiver is fully tunable over the 6-meter band, so you don't have to buy any expensive crystals. Power output on the RT-70 is only about 500 milliwatts, so it definitely is a QRP rig! Of course, you can feed the output of the RT-70 into a 6-meter "brick" RF amplifier (and it does not need to be a "linear amp," since we are working with FM) and boost the power to much higher levels. However, I find it kind of neat to play at the 1/2-watt level with a good antenna and have some real fun on the bands. Prices for the RT-70 are $35-50 for the radio set and about the same for the AM-65 PSU/AF amp.

The PRC-6, PRC-10, and the RT-70 all saw active use well into the Viet Nam era. They were replaced by the AN/PRC-25, a 1–2-watt, tunable (30 to 76 MHz) radio set that was a hybrid design using transistors throughout the radio except for the RF power amp, a 2DF4 vacuum tube. The PRC-25 used a self-con-



Here is the AN/PRC-10, a 1-watt, low-band VHF (38–54 MHz) wideband FM pack-set from the Korean War era. These radios were also used in Viet Nam until they were replaced by the AN/PRC-25, which subsequently was replaced by the PRC-77. The military quickly found that low-band VHF FM communications were well suited to battlefield operations. The PRC-10 is one of a family of pack-sets that covered from 27 MHz (PRC-8) through 54 MHz (PRC-10). The main tuning knob is almost in the center of the front panel, with the analog-dial frequency readout above and to the left. These sets can be carried by one individual using the ST-120A/PR carrying harness, a combat pistol belt, and the M-1945 suspenders. The battery box clips onto the bottom of the radio set. Original BU-279/U batteries are no longer available for this set. However, you can home-brew a battery pack for this radio set using something similar to the one built for the PRC-6.



This photo shows the PRC-10 with its case removed. Note the solid construction. There are a number of modules in this radio which made troubleshooting much easier. The two round connectors on the extreme left of the front panel are two antenna connectors, one for the short (29.5 inches) tape whip and the other for the much longer (10 feet 1 inch) tublar whip antenna. Obviously, the longer antenna made for more reliable communications. However, it also made a bigger target!

tained 15-volt battery in a battery box that clipped to the bottom of the radio chassis. Many guys my age "humped" a PRC-25 in the jungles of Viet Nam. Depending upon whom you talk to, reliability was fair, but coverage suffered. Batteries were always dying about the time an air strike or artillery fire mission was needed!

Enter the AN/PRC-77. This was basically the same radio as the PRC-25, but it was entirely solid state. The 77 had the same physical dimensions as the 25 but used different batteries. These tactical FM radios incorporated a 150-Hz tone squelch system that provided the RTO in the squad with some relief from listening to all the "chatter" on the primary tactical frequency.

Today you can obtain an operational PRC-25 or 77 from various sources on the internet. Prices vary, so be prepared to spend between $350 and $600 for a 77 (less for the 25), depending upon cosmetics and accessories.

Where to Start

There is quite a market for MilCom gear out there, with lots of places to buy from and, surprisingly, prices do vary quite a bit. The best thing to do is to start prowling a MilCom reflector such as <armyradios@yahoogroups.com>, <milpac@yahoogroups.com>, or one of the many military collectors clubs, for example <mrca@mailman.qth.net> (my local group here in the northeast U.S.). Start watching the postings, ask questions (believe me these guys and gals know *everything* about MilCom gear and they are only too glad to help out the newcomer to this facet of the radio hobby), watch the various internet auction sites, and, in general, do your homework before jumping in with both feet.

Procuring, restoring (in some cases), and using these old warhorse radio sets is quite a learning experience. You will have to learn how to speak "Green Radio" language, become conversant using the various acronyms associated with the military, plus you may have to learn a bit about vacuum-tube and solid-state technology in the process. All in all, that's not a bad deal. After all, this radio hobby is a technical one, so why not enjoy the ride, so to speak, and learn a little electronics theory along the way.

Another positive aspect of MilCom radio gear is that by using this gear you are keeping alive a piece of history. Remember these radios were at or beyond the state of the electronics art when they were first designed. They are rugged beyond your wildest imagination. If they could only talk, think of the all the stories they would have to tell. In addition, most of these radio sets and accessories cost thousands or tens of thousands of American tax-payer dollars to produce and field. You can buy these rigs for literally pennies on the dollar and still have a great time using them on the air.

Wideband vs. Narrowband FM

Now a word about wideband FM versus narrowband FM. The military has, up until fairly recently, depended upon wideband FM for its tactical communications. All it takes to make a wideband set compatible with our narrowband ham radio gear is to limit the amount of audio ahead of the modulator. This is done by padding the audio input to the radio, either at the handset/mic or inside the rig near the audio input connector. The best plan is to place a 5K-ohm pot in the transmit audio line of the wideband radio set and listen to the wideband rig with a 6-meter ham band radio while transmitting. Adjust the 5K pot for the best-sounding audio in the narrowband receiver. It's that simple. On the receiving side, turn up your audio gain when listening to a narrowband ham rig on your MilCom radio. Problem solved.

Summary

What I have attempted to do this time around is introduce

you to a facet of the radio hobby that, while not really main stream, is intensely interesting to many thousands of hams worldwide. MilCom radio collecting/usage is not limited to the U.S. amateurs. Not hardly. MilCom radio has a worldwide following, with some of our European ham friends being in the very envious position of having access to a lot of old NATO comm gear that we, here in the U.S., would love to get our hands on. Besides, most of this stuff works on 6 meters quite well, and we all have heard the mantra that we need more activity on 6.

So what are you waiting for? Grab your duffle bag, put on your BDUs, blouse your boots, and get moving, maggot! (Sorry, lost control for a second!)

Tune around 51.0 and 51.6 MHz and listen for some of the MilCom folks using their Green Gear. With the big fascination over the last couple of years being pedestrian mobile operating on HF, how about doing it with a PRC-74, 515, or 1099 attached to an ALICE packframe? Add an HF whip antenna and you're in business! Like I said, this stuff is really habit forming, so be forewarned! In the meantime, get on 6 meters and give it a try.

If you are interested in MilCom, the one book you absolutely need to obtain is *Mil Spec Radio Gear,* by Mark Francis, KIØPF, published by CQ Communications and available directly from them in Hicksville, NY ($27.95 plus s&h). Mark's done a tremendous job of pulling together a lot of gear that is readily available, both HF and VHF, for the MilCom hobbyist. There are chapters on all sorts of gear, including the RT-70,; PRC-8, 9, & 10; PRC-6,; BC-611; PRC-41; and others. Each rig is described in detail, with how to best get it on the air, hints and kinks regarding problem areas on restoration and/or conversion to ham frequencies, what to do if the rig is DOA, etc. In all, *Mil Spec Radio Gear* presents a wealth of first-hand knowledge compiled and written by someone who has been in the hobby for many years. Mark's down-to-earth writing style makes for an easy read. He takes the newcomer by the hand and explains things in detail. If this column has piqued your interest in MilCom gear, get Mark's book. You'll be really glad you did.

73, Rich, K7SZ

By Dr. H. Paul Shuch,* N6TX

1000-cc Science

Do you think maybe you'd like to build a satellite, but are not quite sure where to start? That was the situation facing engineering students at Cuesta College on the central California coast a few years back. Cuesta was well suited to hosting a satellite program, being just under an hour's drive from the U.S. Western Test Range launch facilities at Vandenberg Air Force Base. Our earliest OSCARs had been launched from Vandy. Two Cuesta faculty members—Cliff Buttschardt, W7RR, and Ed English, W6WYQ—had been OSCAR-active since the dawn of the space age. Space was clearly the place, but where to start?

The students' confusion was understandable. It stemmed from the simple fact that every ham satellite to date had been custom-designed around a specific launch opportunity. It was common practice to fit a piggyback payload into a well-defined nook or cranny on a particular vehicle. OSCARs 1 and 2, for example, had semi-pyramidal bodies with curved top surfaces, optimized in mass and form factor to serve as ballast for military AGENA satellites. The Cuesta students and their advisors had no particular launch in mind. They simply wanted to build a ham satellite, stick out their thumbs, and hitchhike into orbit.

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<www.AMSAT.org>

Ed and Cliff had an answer, although it involved a clean break from past practice. Why not, they proposed, come up with a standard package for a small satellite, one compatible with launch from a wide range of boosters? With sufficient standardization, military and civil launch authorities could accommodate such payloads as the ham community might generate, and we could ride aloft on a space-available basis. Thus, the CubeSat concept was born.

Educational ham satellites are not new. Early examples emanated from university labs in Melbourne, Australia, Surrey, England, and Marburg, Germany as far back as the early 1970s. However, the CubeSat concept meant that for the first time *anyone* could play. The actual package constraints were formalized by Bob Twiggs, KE6QMD, and his students at Stanford University. Bob previously had taught at Weber State College in Utah, was the father of their small satellite program, and was the motivating force behind the WeberSat WO-18 satellite. Building upon the Cuesta College concept, the Stanford team came up with a standard cube, 10 cm on a side, 1 kg in mass, to which a whole generation of ham educational satellites was to conform.

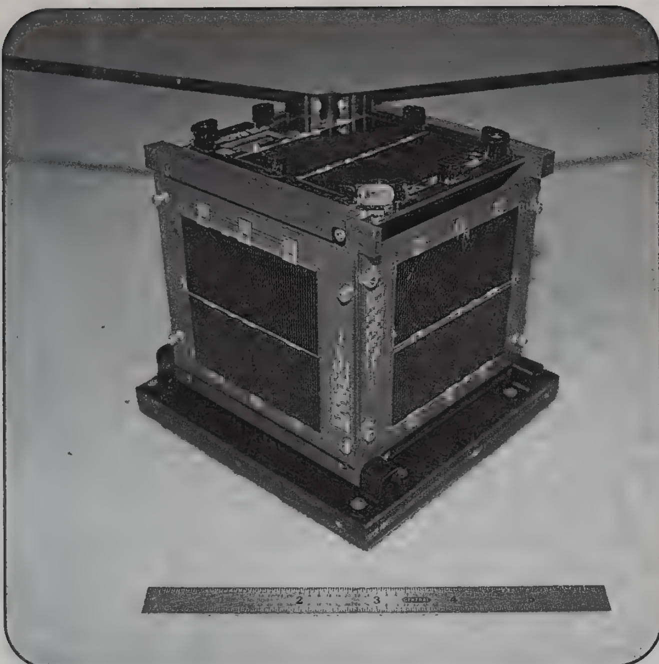
By the time the cube was codified, Ed and Cliff both had retired from Cuesta College and had moved across town to the California Polytechnic University, where they set up a satellite program to further refine the Stanford design. Recognizing that multiple pico-satellites could be accommodated by a single launch vehicle, they set about developing a common launcher interface, which doubled as an orbital insertion mechanism—P-POD, the Poly Picosat Orbital Deployer. This hollow rectangular frame, three CubeSats long, would mount to a variety of launchers with standardized hardware and a well-defined electrical connector. When triggered by a launch-sequence command, its internal ejection spring would spit three peas from the pod and into their individual orbits. Compatible with everything from Delta rockets to converted American and Russian ICBMs, the P-POD concept and CubeSat architecture together began to make satellites, and launching them, truly affordable.

Just how much technology can you cram into a one-liter cube the density of water? A surprising amount, it turns out. Once its mechanical specification was published on the web, school groups around the world started building dozens of educational and scientific missions around the CubeSat standard. These small satellites, covered with solar cells charging lithium-ion batteries, produced 1- to 2-watt power budgets in low Earth orbit, enough to power up a variety of experiments, as well as the 2-meter or 70-cm telemetry and telecommand links needed to support them. As this is being written (summer of 2006), 10 CubeSats are currently operational, with 14 awaiting an imminent launch, and over 50 more under construction around the world.

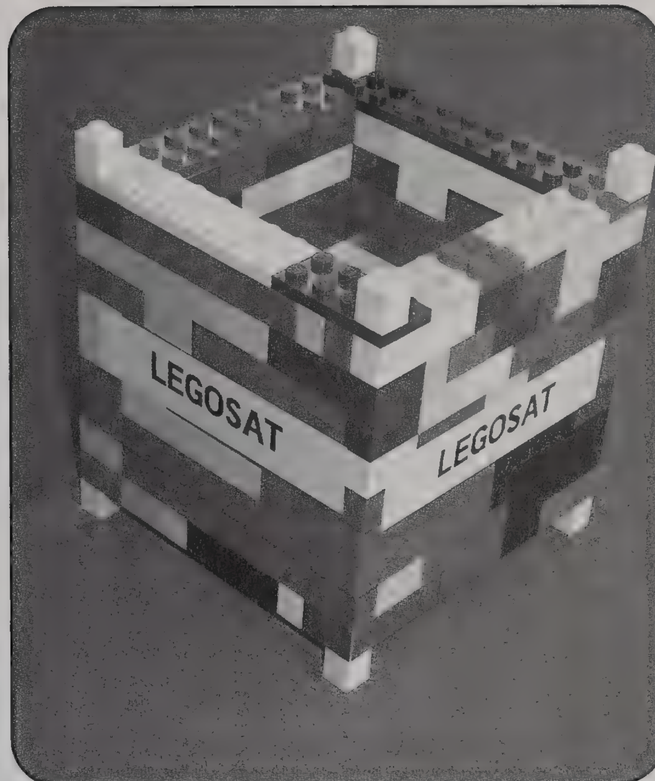
CubeSats are relatively cheap, both to build and to launch. The last dozen specimens averaged about $100,000 U.S. apiece, *including* launch costs. That may be a bit pricey for your pocket, or mine, but it's comfortably within the budget of many an educational institution.

CubeSats are quick turnaround. The typical project spans about two years, from concept to completion. That's comfortably within the lifespan of the average graduate student. Also, CubeSats are accessible, thanks to a high degree of standardization. They're not exactly "Heathkitsats," at least not just yet, but we're getting there. Today you can buy many of the necessary components, including standardized spaceframes and power-system pieces and attitude control systems and datacomm links, all in kit form. These COTS (commercial, off-the-shelf) kits free up your students to concentrate on designing and implementing the mission-specific hardware and software that will make their picosat unique.

CubeSats typically operate in the ham bands. They are eligible for IARU frequency coordination, as long as their command stations are run by licensed



An actual CubeSat, with its tape-measure 70-cm dipole deployed. A 6-inch ruler is shown below it for scale. (W3PK photo)



To become familiar with the CubeSat standardized form factor, students at California Polytechnical University first construct LegoSats, exact scale models built out of—you guessed it—Legos™. (N6TX photo)

radio amateurs within the terms of their individual licenses. It's common for a ham faculty advisor or AMSAT mentor to start the ball rolling. Typically, before their satellite even launches, most of the students on a given CubeSat team will have gotten their licenses. Thus, the potential for recruiting new hams is substantial. These hams are also pre-qualified potential AMSAT members who have already demonstrated a keen interest in satellite technology.

CubeSats end up being built and operated by hams, but are they ham satellites? That depends on how broad a brush you use to paint the ham radio portrait. The primary mission of CubeSats is education. Their secondary mission is scientific. Remote sensing is a popular application. CubeSats monitor everything from seismic activity on Earth to micrometeorite impacts in space, using ham radio to relay their images or digital data streams back to Earth. Therefore, if your notion of ham radio is restricted to ragchews and chasing DX, then no, a CubeSat is probably not a ham satellite.

I prefer to take a wider view, though. Just why should AMSAT, an organization devoted to ham satellites, support the CubeSat concept? Three reasons:

1. Many CubeSats are being designed with a built-in tertiary function, that of data relay. They can be telecommanded from the ground into digipeater mode. Thus, when they're not serving their primary and secondary missions, you will be able to use them as ham store-and-forward birds, for everything from packet traffic to APRS position monitoring.

2. CubeSats have a life expectancy that typically exceeds their mission duration. Students eventually graduate and move on to other things, but their satellites remain in orbit and fully operational. When the scientific instruments are turned off, the CubeSats are able to be repurposed into linear transponders or FM repeaters. Increasingly, CubeSat developers are addressing this eventuality early in the design cycle.

3. CubeSats are a training tool. Amateur radio has an educational mission. The two are highly compatible. Today's students, building and operating small, lightweight, low-power LEO CubeSats, are tomorrow's AMSAT members, designing, building, and operating the most sophisticated high-power, high-orbit amateur satellites you would care to imagine. Work with them now, and they'll work with us later.

Are CubeSats OSCARs? Not all, but some. Those projects that jump through the right hoops (prior IARU frequency coordination, licensing by their respective countries, control stations properly licensed, and conforming to ham radio's usual restrictions on third-party traffic and commercial use) can, if they achieve orbit and are heard on the ham bands, apply for an OSCAR number. True, these are experimental spacecraft. So were our early OSCARs; so, in fact, is every ham satellite to date. By encouraging CubeSat team leaders to apply for OSCAR numbers, we are sending them a powerful message: We hams welcome them into the fold.

How do you go about building a CubeSat? Start with a 10 by 10 by 10 centimeter cube and fill it with a kilogram of electronics. Stuff it into a P-POD along with a couple of its cousins, and hitch a ride into low Earth orbit. Thousands of hams around the world, many of them AMSAT members, are already standing by to track your satellite, copy your telemetry, analyze your data, and stake their claim to 1000-cc science.

So are CubeSats amateur radio? I, for one, vote in the affirmative.

73, Paul, N6TX

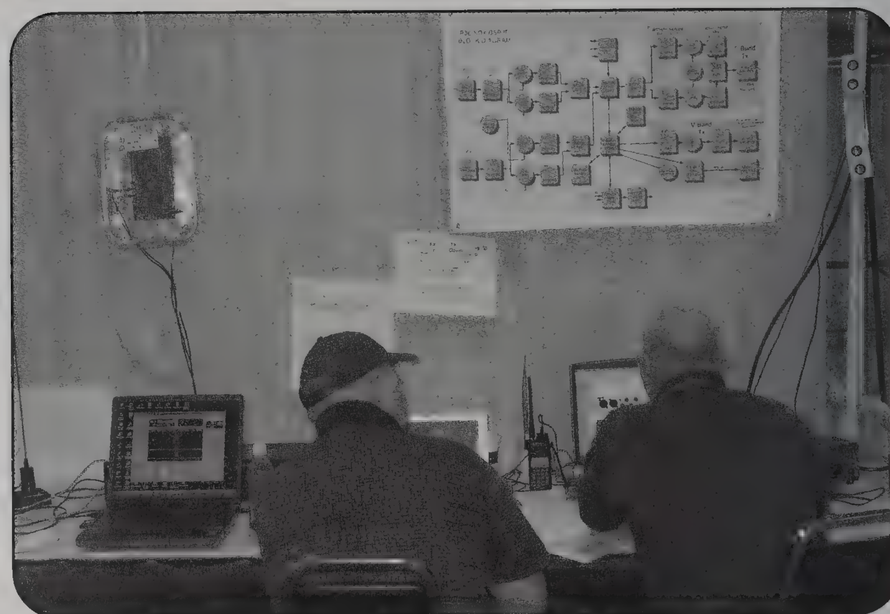
By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

AMSAT's Vision – P3-E and Eagle

The AMSAT forum and the AMSAT booth activity at the Dayton Hamvention® this year featured progress reports on fulfillment of AMSAT's Vision, originally stated in 2004: "Our Vision is to deploy high earth orbit satellite systems that offer daily coverage by 2009 and continuous coverage by 2012..." Fulfillment of this vision will include the launch of P3-E and at least two Eagle satellites. Progress reports on these projects along with the Software Defined Transponder (SDX) are given below.



The SDX (software defined transponder) is shown hanging on the Dayton Hamvention® booth curtain in the upper left-hand portion. Its block diagram is shown in the upper right. WB4GCS and N4HY are shown operating the demonstration.

P3-E

P3-E was started soon after the loss of AO-40 by AMSAT-DL as a means of getting back into high earth orbit as quickly as possible and as a test bed for the German Mars Orbiter Mission. The concept is to borrow as much from AO-10, AO-13, and AO-40 as possible, update it with current technology, and secure a launch to high earth orbit as soon as possible, currently envisioned as sometime in 2007. Peter Guelzow, DB2OS, president of AMSAT-DL, prepared an excellent presentation on the current status and plans for this project. At Dayton, Rick Hambly, W2GPS, president of AMSAT-NA, gave Peter's presentation and emphasized the cooperation between AMSAT-DL, AMSAT-NA, and AMSAT-UK in the development of the spacecraft.

The spacecraft utilizes a space frame left over from the AO-10 and AO-13 days and includes power and control systems similar to the earlier designs. Of course, battery and solar cell technology advances are included in the design where possible. Maximum use of existing, qualified components minimizes the additional qualification necessary on the new spacecraft.

A full suite of modes and functions has been planned which will please both the old and new satellite users. Frequencies utilized range from VHF through microwave. Much of this versatility comes from a decision made in late 2005 to incorporate the Software Defined Transponder developed by Howard Long, G6LVB, of AMSAT-UK.

All of the major functions have been integrated and tested in the space frame and negotiations are under way for a launch currently envisioned for an Ariane V in 2007. Backup plans are being made for a Soyuz in 2008.

Software Defined Transponder (SDX)

Howard Long made an excellent presentation on SDX during the AMSAT Forum at Dayton. Howard and others from AMSAT-UK had been following the SDX ideas and progress being made by Bob McGwier, N4HY, and the Eagle Team in this endeavor. He added some ideas of his own and put together development model hardware and software to support a joint European Space Agency (ESA) and AMSAT-UK project. Howard gained acceptance of his concepts by AMSAT-DL and AMSAT-NA at a meeting in Germany in late 2005. Refinement of his hardware and software has continued and formed the basis of the very successful SDX demonstration in the AMSAT booth at Dayton this year. The hardware and software are currently being integrated into the P3-E spacecraft and are planned for inclusion in the Eagle spacecraft later.

In addition to the mode versatility, low power consumption, and other features made possible by this design, a major improvement in interference and "Alligator" immunity has been incorporated by the inclusion of auto-notching software known as STELLA (Satellite Transponder Equalizing Level Limiting Adaptor). In effect, this software allows notching or reducing multiple high-level "spikes" without affecting the transponder noise floor and low-level signals.

Eagle

Also at Dayton, Jim Sanford, WB4GCS, Eagle Project Manager, made a presentation on the development status of Eagle. While not as far along as P3-E,

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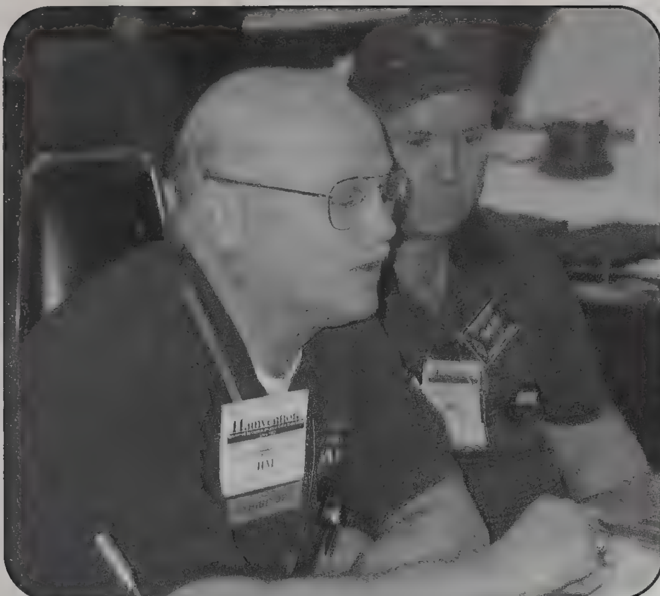

Jim Sanford, WB4GCS, makes contact through the SDX while Bob McGwier, N4HY, watches.

significant progress is being made on Eagle. Jim's presentation outlined the plans for modes and frequencies to be covered by Eagle, as well as the design goals, functional requirements, block diagrams, structure, and schedules. Jim also emphasized the "open design" concept of development and announced the opening of *EaglePedia,* accessed through the AMSAT web page. Emily Clarke, N1DID, implemented this concept on the web page. Through *EaglePedia* any AMSAT member can view most design details of the satellite as the project develops.

Commonality with other projects, such as P3-E, was emphasized by pointing out the SDX, IHU3, and Can-Do Bus modules. A presentation was also made on the development and definition of a set of common module enclosures.

Christina Crawford, KD8DGL, makes a contact via AO-51 with the help of KO4MA while her father looks on.

CubeSat Frequency Summary for July 26 Launch

(Thanks to Mineo, JE9PEL, for compiling the table)

Satellite	Downlink	Beacon	Mode	Callsign
SACRED	436.870	1200 baud AFSK	WA4CEW	
ION	437.505	437.505	1200 baud AFSK	—
RINCON	436.870	437.345	1200 baud AFSK	WA4CEW
ICEcube1	437.305	—	9600 baud FSK	W2CXM
KUTESat Pathfinder	437.385	—	1200 baud AFSK	KCØRMW
nCUBE-1	437.305	—	9600 baud GMSK	LA1CUB
HAUSAT-1	437.465	437.465	1200 baud AFSK	D90HP
SEEDS	437.485	—	1200 baud AFSK	JQ1YGU
PolySat CP2	437.325	437.325	1200 baud AFSK	—
AeroCube1	902/928	—	9600 baud GFSK	—
MEROPE	145.980	—	1200 baud AFSK	K7MSU-1
Mea Huaka'i Voyager	437.405/5.840 GHz	—	1200 baud AFSK	—
ICEcube2	437.425	—	9600 baud FSK	N2VR
PolySat CP1	436.845	—	15 baud DTMF, CW	N6CP

Lou McFadin, W5DID, presented unique new concepts for the Eagle Power System. These concepts included new batteries, new solar cells, and use of large capacitors for energy storage. Significant progress has been made in prototyping some of these concepts, and detailed evaluations will be made before committing to a final design.

And now to add "frosting on the cake." Actual hardware was available for some of these items in the AMSAT booth throughout the Hamvention®. Most spectacular was the SDX live demo. Radios were set up at each end of the booth, and communication was done through the SDX while also viewing the waveforms, etc. Demonstrations were done from the AMSAT outside demonstration area to inside stations through the SDX. It was very encouraging for former users of AO-10, AO-13, and AO-40 to hear the familiar sounds of 400 BPSK telemetry once again. Throughout most of Hamvention®, Jim Sanford, Bob McGwier, Tom Clark, Rick Hambly, and others were available in the AMSAT booth to answer questions and discuss the Eagle project.

Dayton Hamvention® and AMSAT's Youngest Member

All AMSAT activities at Dayton this year went well. The extracurricular activities, Pizza and Suds Bash, and Amber Rose Banquet were well attended. At the banquet we were surprised by a nice donation to AMSAT Satellite Funds from the Hamvention®. AMSAT's youngest member, Christina Crawford, KD8DGL, was introduced and honored with a certificate. Last but not least, Lou McFadin, W5DID, talked about SuitSat-1 and plans for SuitSat-2. Also worth mentioning again is the AMSAT outside demonstration area. This year AMSAT was provided with a fenced-off area near the entrance to the Ball Arena to perform demonstrations. Drew Glasbrenner, KO4MA, spearheaded the demo activity, and several successful demonstrations on AO-51, VO-52, and SO-50 were performed. On Sunday morning Drew was able to assist Christina, KD8DGL, with her first satellite contact on AO-51.

On at least one occasion Drew was able to utilize a new "435/145-MHz Cheap

Satellite station at ARRL/AMSAT, Field Day 2006.

QUARTERLY CALENDAR OF EVENTS

Current Contests

August: There are two important contests this month. The **ARRL UHF and Above Contest** is August 5–6. The first weekend of the **ARRL 10 GHz and Above Cumulative Contest** is August 19–20.

September: The **ARRL September VHF QSO Party** is September 9–11. The second weekend of the **ARRL 10 GHz and Above Cumulative Contest** is September 16–17. The **ARRL 2304 MHz and Above EME Contest** is September 16–17. The **144 MHz Fall Sprint** is September 18, 7 PM to 11 PM local time. The **222 MHz Fall Sprint** is September 26, 7 PM to 11 PM local time.

October: The **432 MHz Fall Sprint** is October 4, 7 PM to 11 PM local time. The **Microwave (902 MHz and above) Fall Sprint** is October 14, 6 AM to 1 PM local time. Note: You are to operate no more than five hours, in one-hour blocks, during this contest time slot. The **ARRL 50 MHz to 1296 MHz EME Contest** is October 14–15.The **50 MHz Fall Sprint** is October 21, 2300 UTC to October 22, 0300 UTC.

November: The second weekend of the **ARRL 50 MHz to 1296 MHz EME Contest** is November 11–12.

For ARRL contest rules, see the issue of *QST* prior to the month of the contest or the League's URL: <http://www.arrl.org>. For Fall Sprint contest rules, see the Southeast VHF Society URL: <http://www.svhfs.org>.

Current Conferences and Conventions

August: EME Conference 2006 will be held in Wuerzburg, Germany from August 25 to 27. For more information about this conference, see: <http://www.eme2006.com>.

September: The 2006 **TAPR/ARRL Digital Communications Conference** will be held September 15–17 in Tucson, Arizona, at the Clarion Hotel, Tucson Airport. For more information, go to: <http://www.tapr.org/>. The unofficial information on the **Mid-Atlantic States VHF Conference** is that, if there is to be a conference, it will be held Saturday, September 30. For further information, please check the Packrats website: <http://members.ij.net/packrats/latest.htm>.

October: The 2006 **AMSAT-NA Space Symposium and Annual Meeting** will to be held October 5–10, in San Francisco, California at the Crowne Plaza Hotel San Francisco Mid-Peninsula Hotel, located at 1221 Chess Dr., Foster City, California. For more information, please see the AMSAT URL pertaining to the symposium at: <http://www.amsat.org/amsat-new/symposium/>. The annual **Microwave Update** conference dates are October 19–22, and it is to be held at the Dayton, Ohio Holiday Inn North Hotel, Wagner Ford Rd., Exit 57B on I-75. For more information, please see the following URL: <http://www.microwaveupdate.org/>.

Quarterly Calendar

The following is a list of important dates for EME enthusiasts:

Aug. 2	First Quarter Moon
Aug. 6	Very poor EME conditions
Aug. 9	Full Moon
Aug. 10	Moon Perigee
Aug. 13	Good EME conditions
Aug. 16	Last Quarter Moon
Aug. 20	Poor EME conditions
Aug. 23	New Moon
Aug. 26	Moon Apogee
Aug. 27	Poor EME conditions
Aug. 31	First Quarter Moon
Sept. 3	Very poor EME conditions
Sept. 7	Full Moon and Partial Lunar Eclipse, Europe, Africa, Asia, and Australia
Sept. 8	Moon Perigee
Sept. 10	Good EME conditions
Sept. 14	Last Quarter Moon
Sept. 17	Moderate EME conditions
Sept. 22	New Moon and Moon Apogee and Annular Solar Eclipse, mostly over the Atlantic Ocean
Sept. 23	Fall Equinox
Sept. 24	Poor EME conditions
Sept. 30	First Quarter Moon
Oct. 1	Very poor EME conditions
Oct. 6	Moon Perigee
Oct. 7	Full Moon
Oct. 8	Good EME conditions
Oct. 14	Last Quarter Moon
Oct. 15	Good EME conditions
Oct. 19	Moon Apogee
Oct. 21-22	Orionids Meteor Shower Peak
Oct. 22	New Moon. Poor EME conditions
Oct. 29	First Quarter Moon; Poor EME conditions
Nov. 3	Moon Perigee
Nov. 5	Full Moon; Good EME conditions
Nov. 12	Last Quarter Moon. Good EME conditions
Nov. 15	Moon Apogee
Nov. 17	Leonids Meteor Shower Peak
Nov. 19	Very poor EME conditions
Nov. 20	New Moon
Nov. 26	Moderate EME conditions
Nov. 28	First Quarter Moon

—EME conditions courtesy W5LUU.

Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers, or for papers to be published in the conferences' *Proceedings,* or both. For more information, questions about format, media, hardcopy, email, etc., please contact the person listed with the announcement. The following conference organizer has announced a call for papers for its forthcoming conference.

Microwave Update: A call for papers has been issue for the 2006 Microwave Update. If you are interested in submitting a paper for publication in the *Proceedings,* please contact Gerd Schrick, WB8IFM, at 937-253-3993 or e-mail: <wb8ifm@amsat.org>. The submission deadline is September 1, 2006. For more information on the conference, please see the website: <http://microwaveupdate.org/>.

Current Meteor Showers

August: The ***Perseids*** meteor shower's predicted peak is around 2300–0130 UTC between August 12–13. According to the International Meteor Organization: "Simulations by Peter Brown made some years ago suggest enhanced ***Perseid*** activity is possible this year, though perhaps not as strongly as in 2004. The timing of any enhancement, though probably not far from the expected spread of possible maxima noted here, is not known."

October: The ***Draconids*** is predicted to peak somewhere around 1430 UTC on October 8, then again around 2220 UTC on October 9. The ***Orionids*** is predicted to peak on October 21.

November: The ***Leonids*** is predicted to peak around 2050 UTC on November 17.

For more information on the above meteor shower predictions see Tomas Hood, NW7US's propagation column. Also visit the International Meteor Organization's website: <http://www.imo.net/calendar/2006/>.

By Chuck Houghton,* WB6IGP

MICROWAVE

Above and Beyond, 1296 MHz and Up

Putting 24-volt Microwave Devices to Use

I have received a few questions about how to utilize surplus 24-volt miniature SMA microwave relays to operate with 12-volt DC power supply systems. This seems to be a common problem in that 24-volt relays appear to be popping up at swap meets in increasing numbers. Don't overlook chassis that have SMA relays internal to the surplus box either. Several dealers have advertised 24-volt relays for a pretty good price, while their 12-volt counterparts are more costly ($25 minimum) and may wind up straining the experimenter's budget.

In that regard, all I can offer is my experience. I pick up SMA coax relays whenever they show up at our local swap meet, or I get them from surplus chassis junk cabinets when they are inexpensive. These relays can be used from low VHF to the upper microwave frequencies, such as 10 GHz. They exhibit great isolation and will handle moderate power for many systems, even my 10-watt TWT (traveling wave tube) amplifier for 10 GHz, where I use four SMA relays to control 10-GHz switching. I might have been lucky, though, as the surplus SMA relays I found have operated quite well for many years.

There are several versions of miniature SMA relays, including the basic SPDT switch, which seems to be most common in the more exotic latching type of relay. The difference between them externally is almost nothing. Internally the difference is quite a bit. In an SPDT-type switch there is only one relay coil internal and the normal contacts are common to one side of the relay with the coil not energized. When energized, the relay switches from common to the other side of the switch and stays in this position until the relay-coil power is removed.

In a latching relay common is tied to one side in a make condition and this side

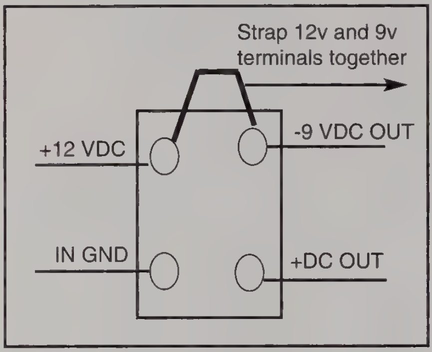

Figure 1. A DC-to-DC transformer, +12 VDC input, isolated output. Read between ground and –9 VDC = 9 volts. Read between ground and +DC Out = 12 volts + 9 volts (stacked in series with +12 VDC. Pulse Engineering part # PE-64430 is good for 400-mA intermittent use.

depends on which set of coils were toggled first. It has two internal coils, and when powered individually, they put the switch in position 1 to common or position 2 to common depending on which coil is powered. Power (current) flows momentarily when the coil is powered to latch the selected position and a cut-off switch disconnects the coil from power. Thereafter no further current flows in the circuit. The second coil in the scenario that was previously open is now closed to the power pin on the relay body and awaits the application of DC power to reactivate it to the make condition.

The switching of a latching relay is simple. It requires two power leads, one for receive and one for transmit. In receive common, contact is made. When transmit DC is applied to the second coil, the relay switches to the transmit common part of the switch, making the transmit contact open from common.

Other relays operate from TTL control voltages and have lamp control leads to show which portion of the coax relay is active to ports 1 and 2. If you can't figure out the contact pins' logic, try looking on the web for your part number and see what you come up with. You could just probe the relay, trying your luck, but be careful, as some relays use small steering diodes internally, and if they blow, you will need to open up the relay and possibly replace a diode. Small glass signal diodes are normally used here. If you're totally stumped, drop me an e-mail and I'll see if I can figure it out.

How to Use 24-volt Relays

The main topic to be discussed here is how to use 24-volt surplus relays from 12-volt DC sources, as in mobile or remote Field Day operations. Of course, you could power your equipment from a 24-volt battery source, but that requires carrying an extra battery.

Electronically speaking, what can be done to accommodate this power problem by using surplus 24-volt microwave relays and adapting them to 12-volt power systems? There are two solutions. One requires construction of a bucking voltage doubler. The other requires adding a miniature surplus switching power supply whose isolated DC can be put in series on top of the 12-volt control switching-relay power line. In actual operations, the latter is simple, if you can obtain such a power supply. Check surplus scrap yards that break down computers and other electronic equipment.

These switching power supplies are fairly common and might have been overlooked for many applications. They are quite small—about 1/2 inch wide and less than 2 inches square. They are rated for various voltage inputs and outputs, but the ones that seem to be just what we want are those that operate from +12 volts input and deliver +5 volts output. Most of these can handle at least 5 watts of power output at 5 volts and can be used normally or inverted for negative power requirements. This is because the power module output is not just a voltage regu-

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lator internally, but is a complete switching power supply whose input is totally isolated from its output.

Take the +12-volt normal battery supply and attach it to the DC module 12-volt input, plus to plus and minus to minus. Take the –5-volt lead from the DC module and connect it to the positive 12-volt lead, making a direct connection to the +12-volt DC lead. Now at the positive 5-volt lead you have +17 volts available. Connecting two of these in series gives you 22 volts. That's 12 volts from the primary power source and two 5-volt isolated power supplies stacked in series, each adding 5 volts to the picture for a total of 22 volts. With mobile operations and a charging 12-volt battery source, it will up the voltage on these connections to 24 volts, as the charging 12-volt battery nominally is now +13.9 or so, plus one or two series-isolated DC power modules. It's very simple and just like stacking batteries in a flashlight.

Why 5-volt switching power supplies? They are the most common for providing +5 volts DC for logic power on PC boards. While there are other voltages that fit the bill, the 5-volt switchers seem to be the most plentiful.

One other surplus item that I located quite some time ago was +12-volt input and 9-volt isolated output switching power supply in a square package. There was no label, but I knew it was a switcher, as it had only four leads internal to the sealed epoxy package and resided on the DC power supply shelf of the scrap PC board from which it was harvested. Once I recognized it for what it was, I obtained many more, as I knew what to look for. The label on some said part # PE64430.

Some part-number schemes seem complex, and while others are not. Take, for example, a surplus ASTEC power switcher with a label that says AA10B-12L-050S. While I don't know the complete information on this unit, it has been observed that it's +12 volts input and 5 volts isolated output. I have stacked one power module on top of a 12-volt DC line, and with the 17 volts have been able to use with confidence many 24-volt relays with out further modification. Adding another switcher of 5 volts isolated output gets you 22 volts for 24-volt relay-switch applications that function just fine.

Another great application is the generation capabilities of using this power module in an inverted power connection for FET bias supplies. This allows you to use a lower voltage DC positive drain power source and a negative 5-volt supply from the switcher for gate FET bias. Of course, further circuitry is necessary in any FET power supply circuitry, but the basics are there for both positive- and negative-generated voltages.

Testing the power module that did not have a label and that put out 9 volts isolated on the secondary of the switcher, I found that with a 75-ohm load it was still loafing along at 125 ma current draw. Testing it with a 24-volt relay that drew 95 ma, the unloaded power supply was 22 volts, and it did not change a tenth of a volt when power was applied to the 24-volt relay. It operated quite well on 22 volts. I was watching contact closure for relay operation with a simple LED-driven test circuit I use for coax relay contact testing.

That's just another simple idea for testing miniature SMA relays. The project is constructed out of some scraps of SMA connection coax cable tied to two LEDs operating on low voltage for watching contact closure of the relay. Being a scrounger and finding a relay that was defective, I felt I could use this simple tester to verify if and when I obtained contact closure on a few relays. It was easier to use this simple test setup than to hold a VOM set of test leads.

Most relays that I have found to be defective had dirty contacts internal to the relay. If you can pry off the cover without destroying the relay, through some simple repair you too might get lucky in salvaging a defective SMA microwave relay.

Well that's it for this time. Don't scowl at the next batch of SMA microwave relays just because they are only marked 24 volts. Take advantage of these 24-volt relays, be they SPDT, latching, or even the harder to find transfer (four-contact) relays. If you can't locate the DC-to-DC switching supplies locally, I have a small supply of both the 5-volt and 9-volt switchers available for $4 each for the 9-volt switcher and $5 each for the 5-volt switcher (continental U.S. only, and please add $1.50 for handling and postage costs).

As always, if you have any questions, please drop me an e-mail (clhough@pacbell.net), and I will answer you as soon as possible.

73, Chuck, WB6IGP

By Del Schier,* K1UHF

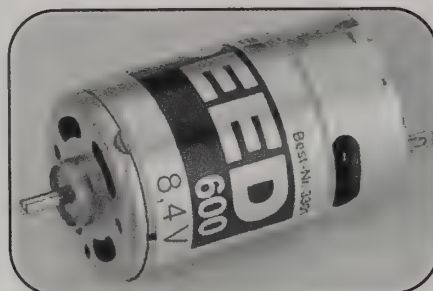
Electric Power Systems

These days, electric airplanes are "where it's at." Technology in the form of lithium batteries and brushless motors makes electric power as good as wet-fuel power. Little glow plug and ignition engines work great, but they are a hassle and messy. Electric power is clean and easy.

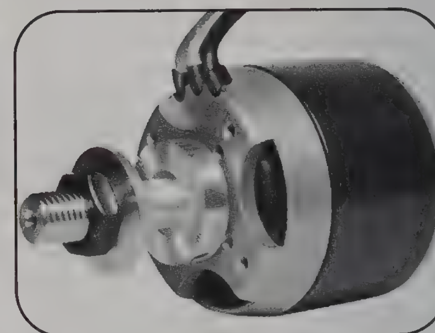
RC airplanes have been flown with electric motors for many years, but until recently they used DC brush motors with nickel-cadmium batteries. While this older technology still works well and is inexpensive, lithium polymer batteries with three phase AC brushless motors offer a big improvement, especially in the power to weight department. Higher power to weight ratio gives higher performance and flight times.

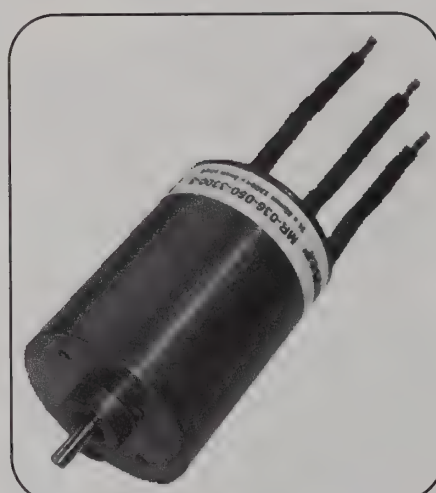
Deciding on the best power system for an airplane can be complicated unless you purchase an airplane with a power system that a dealer or manufacturer correctly recommended. The advice of the supplier is a good starting point, but you still need to have an understanding of what your choices are.

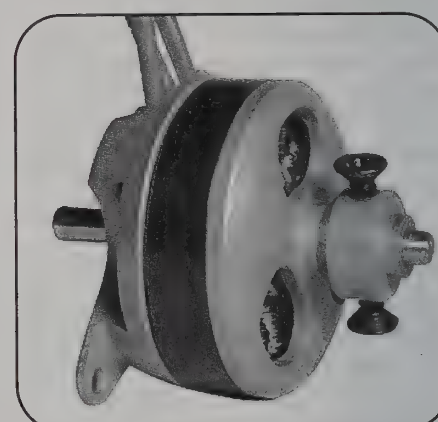
A power system isn't just the battery and motor. It is also the speed control and propeller, and yes, the propeller may be the most important part. All of the pieces are highly interdependent, and the entire package must match the airplane.



A 600-size cordless drill brush motor.


58 amps at 36 volts AXI outrunner, 600 grams.


A Medusa Research Afterburner inrunner brushless motor.


A small AXI brand outrunner motor, 9 grams.

Motors

DC brush motors are inexpensive, $10 or less, as they are made in quantity for cordless drills and screwdrivers. You will also find tiny pager motors or cordless toothbrush motors in smaller airplanes. Mass-produced brush motors are called "can" motors, as they have stamped steel can housings. They usually have bronze bushings or sometimes ball bearings, and they use ferrite magnets. They come in a variety of sizes with numbers such as 350, 380, 400, and 600. A 400 size from a cordless screwdriver is a popular size for many airplanes, and a 600 from a cordless drill will power something larger. These motors range in power input from 80 to 250 watts. Compared to the more expensive brushless motors, they are heavier, lower in efficiency, have shorter life spans, and produce RF brush noise. The efficiency of a inexpensive brush motor is in the range of 40 to 60% and will be worse if it is run backwards. They have a fixed timing advance, and reverse operation kills the performance. Nevertheless, do consider these motors, because they are an excellent choice for the money and can be lots of fun. I have a 400-powered airplane with hundreds of flights on the original motor, but it is on the third battery pack.

The new rage in brushless motors made specifically for RC models is available from dozens of companies. These exotic motors are state-of-the-art and are available in just about any size or type. They range in power from a few watts to 10 kW. A 5-watt motor is the size of a thimble, and 10-kW motor is about the size of an orange. Ten kW is the equivalent of 15 horsepower and produces 66 pounds of thrust. To my knowledge, all brushless motors are three-phase AC motors with ball bearings. They use the best rare-earth magnets to achieve efficiencies of 80 to 95% or more. Without brushes to wear out and ball bearings, they last virtually forever. These motors came from computer technology, as CD-ROM drives and hard drives use AC brushless motors. In fact, RC modelers convert CD-ROM motors for use with model airplanes.

Brushless motors come in three basic styles: inrunners, outrunners, and gear drive. Inrunners are the familiar design with the rotor having the magnets and the

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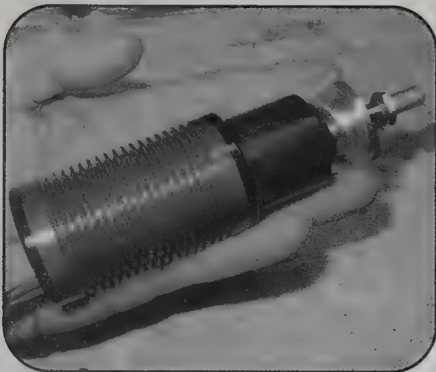
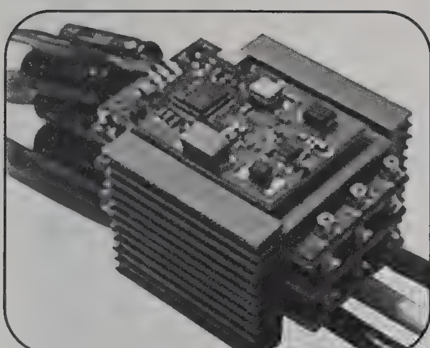


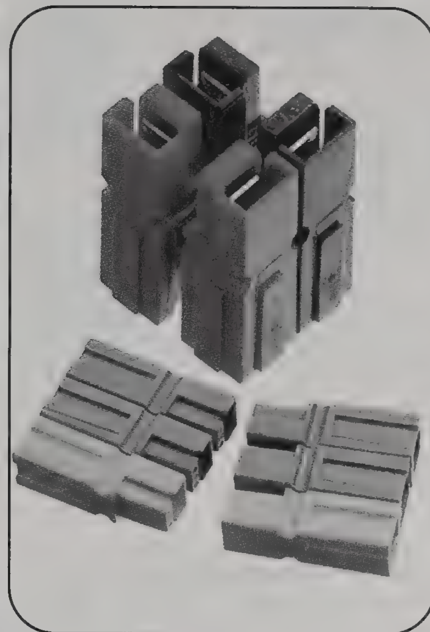
A big Hacker Gear motor that will put out well over a horsepower.



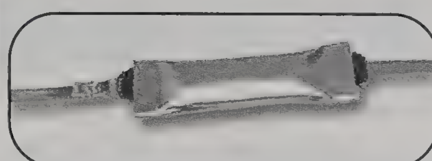
A super-large 10-kW brushless speed control.

A Hacker Inrunner with about 200 watts of output.

stator having the windings. An inrunner runs at high rpm. To operate at 30k to 40k rpm the prop must be small, which gives lower prop efficiency. Adding a planetary gearbox allows operation with a larger diameter prop, which gives higher system efficiency. Brush motors work well with gearboxes also. Outrunner brushless motors have the windings in the center with a large-diameter outer rotor. The large outer rotor provides the same power but at lower rpm, so it does not need a gearbox. The outrunner, without a gearbox, is a simpler solution because of the



Powerpole connectors connect an airplane or your ham station together.



A micro 20-ma-hr cell for an indoor airplane.

lower weight. Outrunner motor efficiency is down a bit, but gearboxes create friction and running a large efficient prop is usually more important.

Electric motors are controlled by an electronic speed control, ESC for short. An ESC is connected to the throttle channel of the receiver and gives full proportional control of the power. ESCs come in two types: DC for a brush motor and three-phase AC for brushless.

ESCs use switching FETs to control the pulse width sent to the motor. A micro controller usually does the work of generating the signal. These speed controls can be custom programmed for items such as timing, braking, soft or hard start, and other features. The programming is done with a sequence of moving the radio's throttle stick or with a USB or serial computer interface.

Lithium polymer batteries do not like being discharged much below three volts per cell, so modern ESCs have a cutoff feature to cut back the motor power when the battery reaches its minimum. ESCs also have battery eliminator circuits (BECs) to regulate the motor battery voltage by cutting the power to the motor when the battery gets low and thereby allowing for a safe amount of time for a gliding landing to take place. This provision allows for the airplane's receiver and servos to continue to function without the need for a second battery (and the added weight). The BECs connect the power through the throttle channel connector. It is important to note, however, that the BECs may or may not be able to run all of the servos in an airplane. Therefore, it is important to consider how many servos should be onboard the plane. This is particularly important in a larger model plane.

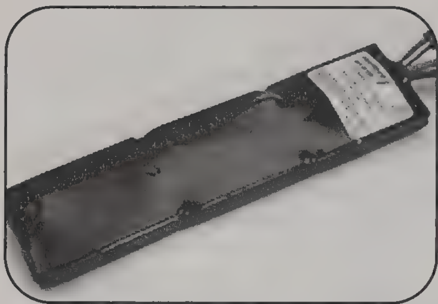
To connect the motor and the battery to the ESC, you need good high-current connections. Usually I solder the ESC to the motor leads and use Anderson Powerpoles™ for the battery side. There are many other connectors for this purpose, but Powerpoles are usually the best choice.

RC propellers are not usually variable pitch, so an airplane is like a car or bicycle with only one gear. I say "not usually," as I have a Great Planes V-Pitch prop on an aerobatic airplane that can fly backwards—yes, backwards. Since the propeller has a fixed pitch and diameter, it must be chosen carefully for a good compromise in performance. The wrong prop can cause an airplane to fly poorly or not at all, and the wrong one can burn out the motor and ESC. Burning things up is a real issue. You not only need a matched setup, but you also need cooling air past the motor, ESC, and battery.

The motor/prop combination should be matched to draw a current level for best power and efficiency. The prop should be matched to the airplane for a compromise between climb thrust and top-end speed. The ESC needs to have a rating higher than is dictated by the motor/prop/battery combination.

The battery needs a capacity for good flight times, and it needs to be able to supply the power without it overheating or sagging in voltage under load. There are many tradeoffs when choosing a battery. With the nickel-cadmium chemistry's weight and size, it is usually a matter of putting the biggest battery in the airplane that will physically fit and still let the airplane fly. Of course, you still need to consider the voltage and capacity.

Lithium polymer packs have "C ratings" to indicate their ability to provide source current for the power being drawn. A "C rating" is the capacity rating times a number as the maximum current that will supply intermittently. You will see



A Thunder Power 2-amp-hr 11.7-volt pack that weighs only 9 oz.

An FMA Cellpro battery that will fly a 40-inch airplane for a half hour.

packs rated 7C, 10C, 20C, but remember that these are intermittent, or "burst," ratings. This gets a bit complicated, as it depends on how the airplane might be flown, and also the ratings may be unrealistic. Some airplanes fly with short bursts of throttle, while others fly flat out for the entire flight. The C ratings are supposed to be a function of the pack's internal resistance. For instance, a 3200-maHr pack with a 20C rating will supply 64 amps on short bursts. If it is a quality pack, it would be all right to fly with short full-throttle runs at 64 amps. However, for an airplane that always has the power on, 35 amps may be the max. Note that it depends on the quality of the pack and whether or not the ratings were realistic. A West Mountain Radio CBA can be used to determine internal resistance and to project the pack's heating and voltage drop under load. A quick static run with the motor will also show the pack's quality in terms of voltage drop and heating. If a fully charged lithium pack goes much below 3.4 volts per cell at a motor's full power draw, the pack may be damaged or not last after many charge cycles.

You do not need to trust the recommendation for an airplane. You can verify the match of the equipment with some calculations of your own. The amount of power the airplane needs depends on how you expect it to fly. Power requirements are usually specified in watts per pound. Generally, 30 W/lb is the minimum for mild performance and 150 W/lb will give super performance. At the low end, the airplane will take off and climb, but slowly. With high power it will accelerate vertically or be able to hover on the propeller at one-third throttle, provided it can be controlled in a hover. Remember, amps times volts equals watts. When calculating watts, consider that a battery's voltage will drop under load and as it discharges.

Propellers

You need to make sure you have the correct propeller. You can go online to motor manufactures' web pages to use web-based motor system calculators, but only for their motors. To select among many motors you can download and try either MotoCalc or Electricalc software, which figures out everything from a large database of motor, battery, and propeller specs. This software is a good way to check power systems before you buy or if you think you have a problem with a given setup.

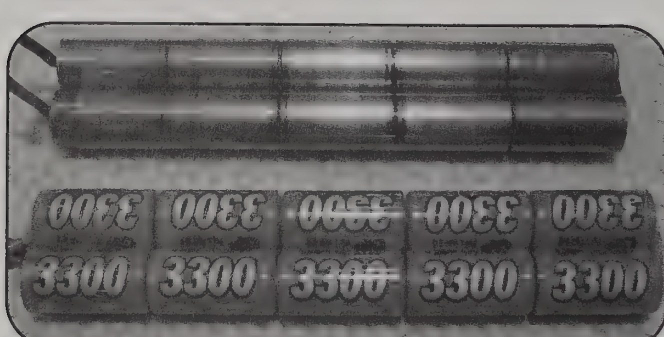
Assuming you have done your homework and have picked a good power system, you still need to test it before you fly. Do a static run. A static run is very similar to what real airplane pilots do each time before they take off. On the bench, run the motor and measure the power with a meter, such as one from Astroflight or Medusa Research. A static run is a simple test to measure volts, amps, and power with an airplane stationary on a bench. Along with a static power test I also measure the thrust with a spring scale and the rpm with an optical tachometer.

A static power check is only good if the power does not exceed maximum ratings of the equipment you are developing near full power. To adjust the power, change the prop or battery. A larger or higher pitch prop gives more load on the motor and therefore more power. A larger capacity battery with lower internal resistance increases the voltage and power. More cells in a pack will have a large effect on the power. Remember that airplanes do not stand still when flying. A prop behaves differently with air moving over it. During a static run, a prop may be aerodynamically stalled and produce little load. At high speed, a prop unloads and the motor turns higher rpm with the lighter load. A static run tells only some of the story, but with the right numbers you can be fairly sure that you will not smoke your new power system and the plane will fly.

Note: Be very careful whenever you run a motor on a model airplane! Use care whenever you have power connected to the motor. ESCs have safety arming devices, but you must keep clear of a prop whenever power is connected. An electric drill motor may not sound dangerous, but a prop rotating at 20,000 rpm can cause serious injury.

Flying

Once you think that everything is ready to go, you need to do a radio check to be sure that there is no serious interference from the motor. You can lose control of your new airplane because of this! To do a range check, have a helper hold the airplane while you test all of the controls at



Heavy, but effective NiCad flight packs.

Links

AXI motors: <http://www.hobby-lobby.com/>
Astroflight: <http://www.astroflight.com>
Electricalc: <http://www.slkelectronics.com>
FMA Direct: <http://www.fmadirect.com>
Medusa Research: <http://www.medusaproducts.com>
Motocalc: <http://www.motocalc.com>
Neu Motors: <http://www.neumotors.com>
Hacker motors: <http://www.hackerbrushless.com>
Northeast Sailplane Products: <http://www.nesail.com>
West Mountain Radio: <http://www.westmountainradio.com>

The West Mountain radio CBA will test just about any battery.

An Astroflight Whattmeter goes in line to measure a power system on the bench.

various throttle settings. Put the transmitter antenna fully down and walk away at least fifty feet and make sure you have no loss of control. If you have any glitches, do not fly. Go back and reconfigure your antenna or motor installation. Keep the antenna away from the motor and ESC wiring. Make sure that your brush motor has suppression capacitors on its terminals.

Flying is the only thing that will tell you how well you made your choices and how well your power system works. If your flight times are less than you expected, or the power drops off rapidly, you may have a battery with low capacity. Check the capacity with a West Mountain Radio CBA. If you find your airplane takes off and climbs very well but it doesn't cruise too fast, you might try a prop with more pitch but perhaps less diameter. If you have the reverse problem, go the other way. If your power system cuts out prematurely, you may have a cooling or overcurrent problem. ESCs have thermal and over-current protection.

That's it for now. I must go QRT, but look for more on this subject in future columns. Happy flying! 73, Del, K1UHF

By Bob Witte,* KØNR

FM/Repeaters—Inside Amateur Radio's "Utility" Mode

Mountaintop Operating with FM VHF

The warm summer months are upon us, so it is a good time to get outdoors with the FM VHF gear. One fun activity is to find a local high spot for some mountaintop VHF simplex.

Mountaintopping

We generally think of the VHF and higher bands as having "line of sight" propagation. Sure, there are exceptions such as sporadic-*E* propagation, but on a day-to-day basis, VHF is all about line of sight. This naturally drives us to improving our line-of-sight distance by increasing our HAAT, or height above average terrain (photo A).

One of the most well-known and easily accessible mountains in North America, Pikes Peak, is practically in my back yard. At 14,110 feet above sea level, it is not the tallest mountain in North America, but it is one of the most well-known peaks. It is relatively easy to access, since there is a maintained road that allows you to drive to the top. If you don't want to drive up, you can always ride the Pikes Peak Cog Railway. For the physically strong, the Barr Trail provides a not-so-easy hiking route to the summit (10.7 miles and 7400 feet in elevation gain).

Whenever visiting hams find their way to the summit, their next move is entirely predictable—turn on the rig and give a call. During the summer months it is common to hear radio operators call CQ on 146.52 MHz FM from Pikes Peak, testing out their temporary but dramatic improvement in HAAT. This type of mountaintop operating is loads of fun. (Not only is VHF FM the utility mode, it is also the *fun mode*.) You never know who will come back to you . . . someone in nearby Colorado Springs or a station over 100 miles away.

Another popular mountain in Colorado with a road to the top is Mount Evans, at 14,264 feet. The road up Evans is the highest paved road in North America and is in better condition than the Pikes Peak Highway, so we often hear mountaintopping hams calling CQ from that peak. Evans is about 55 miles from my house, and I can easily hear anyone transmitting from that summit.

There are 54 peaks in Colorado with summits that are 14,000 feet or higher in elevation. A popular recreational activity is climbing to the summits of these peaks, commonly referred to as the "fourteeners." These fourteeners range in difficulty from those that can be driven up (Pikes and Evans) to ones that are a serious technical climb. Radio amateurs who also like to climb these peaks usually carry with them a handheld VHF radio. The natural desire of radio hams to operate from a high spot has produced an operating event in August called the Colorado

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Photo A. Bob, KØNR, operating VHF FM from a mountain pass near Comanche Peak in Colorado.

14er Event. On a designated day, a bunch of hiking hams go out and operate from the summits of these mountains, working each other and working anyone else within range (photos B and C). While 2-meter FM is the most popular mode, any band or mode can be used.

The Colorado 14er Event is not a contest, but we do have an awards program for contacts with stations on the 14er summits. Contacting 15 or more of the recognized 14er summits earns the Summit Award, while *activating* 5 or more summits qualifies for the Pinnacle Award. These awards can be endorsed for a particular mode, band, QRP, etc. Any contact throughout the year qualifies for the award, not just contacts during the 14er event.

The 2006 Colorado 14er Event will be held on Sunday morning, August 13th. The primary operating hours are from 9 AM to noon local time so that the hikers can get off the summit before the afternoon thunderstorms roll in. See the 14er.org website for more details.

High Points

Not everyone has Pikes Peak in sight of their house, so I started thinking about mountaintopping locations in other states. Some searching on the internet found a great website (America's Roof) that has cataloged the high spot in every one of the U.S. states. In addition, the Highpointers Club was formed to promote climbing to the highest point in each of the 50 states. There is something about the human condition that causes us to establish goals, create lists, and pursue "checking the box" on some arbitrary activity. For hams, it might be making contacts with all of the states to quality for Worked All States. For Highpointers, it means climbing the 50 state high points. I use the word "climbing" loosely, as in many cases you can just drive to the high spot. In other cases it is an easy walk. On the other hand, the high spot of Alaska is Mount McKinley, 20,320 feet in elevation, requiring a trek of 23 miles (one way) . . . a challenging climb.

I took a look at the list of state high spots with an eye toward summertime VHF mountaintop operating. Mount Greylock is the highest point in Massachusetts and is the site of the legendary Mount Greylock Expeditionary Force VHF contesting group. Yes, you can drive up Mount Greylock, so it is very accessible. Mount Mitchell at 6684 feet in elevation is the highest point in North Carolina and the highest point east of the Mississippi River. An observation tower is located at the summit, which can be reached by walking about 0.2 mile. Next door in Tennessee, the highest point is Clingmans Dome, a popular spot in Great Smoky Mountains National Park. This summit also has an observation tower, which can be reached by a half-mile walk. At a much lower elevation, the highest point in Ohio is Campbell Hill, at 1550 feet in Logan County. According to the America's Roof web page, Florida has the lowest high point of all the states, which is Britton Hill, elevation 345 feet.

Take a look at the Americas Roof website to determine the highest point in your state. Of course, the highest spot in a state may not be the best place to try radio mountaintopping. It might not be easily accessible, and it doesn't necessarily have good line-of-sight propagation to populated areas. The Americas

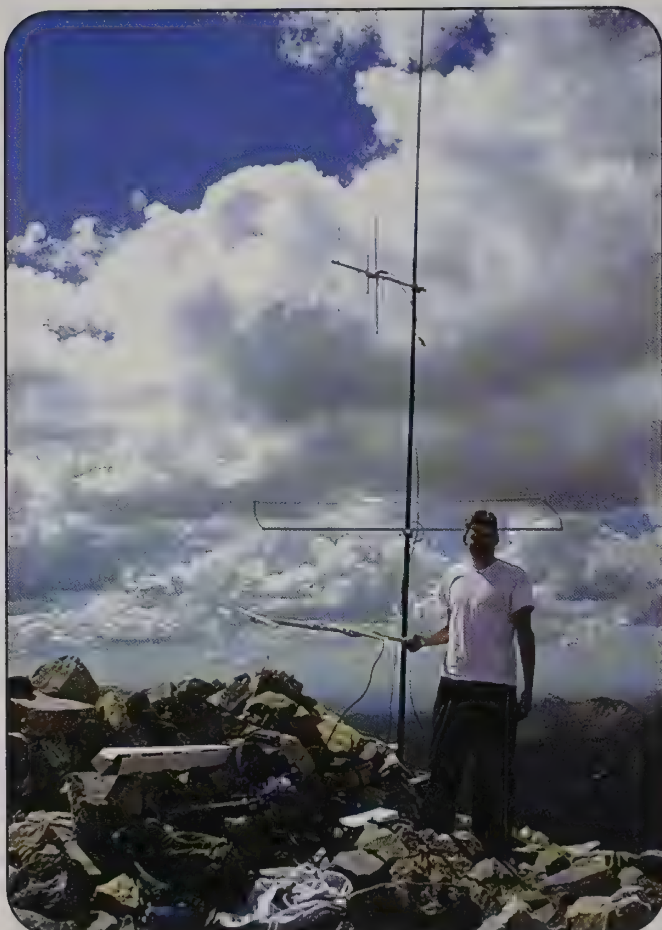

Photo B. Chris, KØCAO, doing some mountaintop operating during the Colorado 14er Event. (Photo courtesy of KØCAO)

Photo C. Peter, K3OG, operating from Grays Peak during the Colorado 14er Event. (Photo courtesy of K3OG)

Roof site also lists the highest 100 spots in each state, which may be helpful in locating a good radio hill. You may already know about some great locations in your corner of the world that would be great for radio mountaintopping. Ask some of the local VHF enthusiasts; it is likely that some of them have already scoped out the best VHF operating locations.

Wilderness Protocol

Summer is a good time to remind everyone of the *Wilderness Protocol.* From the ARES Field Resources Manual:

> The Wilderness Protocol (see page 101, August 1995 *QST*) calls for wilderness hams to announce their presence on, and to monitor, the national calling frequencies for five minutes beginning at the top of the hour, every three hours from 7 AM to 7 PM while in the back country. A ham in a remote location may be able to relay emergency information through another wilderness ham who has better access to a repeater. Calling Frequencies: 52.525, **146.52**, 223.50, 446.00, 1294.50 MHz.

The basic idea is that there are still places on Earth without mobile phone coverage, or even ham repeater coverage. Therefore, give a listen on the standard VHF/UHF calling frequencies. The primary Wilderness Protocol frequency is 146.52 MHz, with the other calling frequencies considered secondary. For completeness, the Wilderness Protocol lists all of the FM calling frequencies for the most common VHF/UHF bands. (One could make the argument that the other calling frequencies are superfluous at best and perhaps an unnecessary distraction.)

In the Fall 2005 issue of *CQ VHF* ("FM Simplex on the Road"), I gave some tips on how to keep an ear on 146.52 MHz when mobile. These ideas apply equally well to mobile and portable operation.

Mountaintop Operating

For summits that you hike to, you'll want to keep your radio gear light. For VHF or UHF FM, the obvious choice is a handheld transceiver. However, the usual "rubber duck" antenna is very inefficient, so consider taking along a more efficient antenna (photo D). Telescopic antennas that are a half-wave on the band of interest usually work particularly well. A small Yagi antenna is another good choice, since it provides gain without being too heavy. Don't forget a spare battery pack or two, depending on how long you expect to operate. It is bad news to be making a run of contacts only to have your battery go dead.

For high points that you can drive to, a mobile station with a reasonable vertical antenna will do the job. Some mountaintoppers take along a portable mast to gain additional HAAT, with either an omnidirectional antenna or a Yagi. If you use the car battery to power the rig, be aware of how long you operate so that you don't run down the battery. (I have this "friend" who did that once.)

Figure 1. Map of the across-the-water 2-meter FM contact between KØNR and W9ZL.

Beach Operation Across the Water

Summertime operating is not just for the hills. During July 2005, my wife and I were walking along the beach on the eastern shore of Lake Michigan in Ludington State Park to the Big Sable Point Lighthouse. While we waited for the lighthouse to open, I was listening to 146.52 MHz on my Yaesu VX-2R handheld radio. I heard a signal coming through which turned out to be W9ZL calling. This was a special-event station, so I figured they were operating from one of the lighthouses or other location close by.

I wasn't sure where W9ZL was located, but I soon found out that it was the Fox Cities Amateur Radio Club operating at AirVenture, the famous Oshkosh, Wisconsin experimental aircraft show. This special-event station was operated by Bernie, N9YMC. Of course, this was on the "other" side of Lake Michigan, and a significant distance into Wisconsin (figure 1). I worked W9ZL using just 2 watts from the little HT. Later, I calculated that the distance of this QSO was a little over 100 miles, about 60 miles across Lake Michigan and another 40 miles across land. Not too bad for VHF QRP (with FM)!

Calling Frequency

What frequency are you going to use to call CQ from your favorite high spot? Well, the calling frequency, of course—most likely 146.52 MHz. This usually works pretty well, as many simplex-oriented operators make it a point to listen on .52. While we don't normally make long CQ calls on VHF FM, making a call such as "CQ Five Two, this is K Ø N R on Pikes Peak" is a good way to go.

One problem I've run into is when the calling frequency is tied up with lengthy contacts by other hams. If the frequency is in use, I generally just stand by and wait for them to finish. If it seems appropriate, I might break in and chat with them.

Disclaimer: It is difficult to write authoritatively in a national ham magazine about VHF issues that often tend to be regional in nature. What works in rural areas with lower population density may not apply in New York City. Ignoring that, I'll jump in with both feet (maybe with one in my mouth; who knows?).

What is the purpose of a calling frequency? Back in the old days of crystal-controlled rigs, it was important that we had common channels crystalled so we could talk to one another. We typically only had a dozen or so channels, so having a common calling or simplex frequency (or two) was an obvious thing to do. These days, we have synthesized 2-meter FM rigs that cover the entire 4-MHz band in 5-kHz steps. Now the purpose of a calling frequency is, well, for *calling*. You use 146.52 MHz when you want to establish contact on the band, lacking any other information. For example, if I know my buddy Steve, KØSRW, is going to be listening on the 146.94-MHz repeater, I'll call him there. If I know the local DX crew hangs on out 146.46 MHz, I'll make a call there. However, when I don't have any other information, and I am making a call or listening for a call, I go to the calling frequency. Why? *Because that's what*

Photo D. Longer antennas provide better performance than the standard short "rubber duck" antenna.

it's for! If I am out of repeater range and I just want to talk to someone on simplex, I try the calling frequency.

The Three-Minute Rule

There are two ways to make a calling frequency useless:

1. No one ever uses the calling frequency (nobody there, nobody home).
2. The calling frequency is always tied up due to lengthy contacts.

Thus, we need to encourage hams to monitor and use the calling frequency, but not monopolize it. We don't have to be extreme about it. Perhaps a "three-minute" rule of thumb: If I am in a contact with another station on the calling frequency for more than 3 minutes, it is time to change to a different frequency. This opens up the frequency for other hams to use it. Just as important, it keeps the long ragchew sessions away from the calling frequency. These long sessions have a tendency to discourage monitoring of 146.52 MHz. One ham recently told me that he tries to keep a receiver tuned to .52 for anyone just passing through the area who might need some help, but when some of the locals get on the frequency and chat for an hour, the radio gets turned off.

There, I said it: *The calling frequency is for calling, not for ragchewing.*

VHF/UHF FM Calling Frequencies

6 meters	52.525 MHz
2 meters	146.52 MHz
1.25 meters	223.50 MHz
70 cm	446.00 MHz
23 cm	1294.5 MHz

Summary

I hope this article stimulates you to do some portable FM VHF operating. I'd love to hear about interesting hilltops and VHF contacts that you've experienced. Let me know if you have thoughts on the use of 146.52 MHz. Whatever you do, get outside, turn on the radio, and have some fun. Also, visit my weblog at <k0nr.blogspot.com>.

73, Bob KØNR

References

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Colorado 14er Event website: <http://www.14er.org>.
Americas Roof (high points in 50 states): <http://americasroof.com/usa.shtml>.
Highpointers: <http://highpointers.org/>.
Mount Greylock Expeditionary Force (W2SZ/1): <http://www.mgef.org>.
ARES Field Resources Manual: <http://www.arrl.org/FandES/field/aresman.pdf>

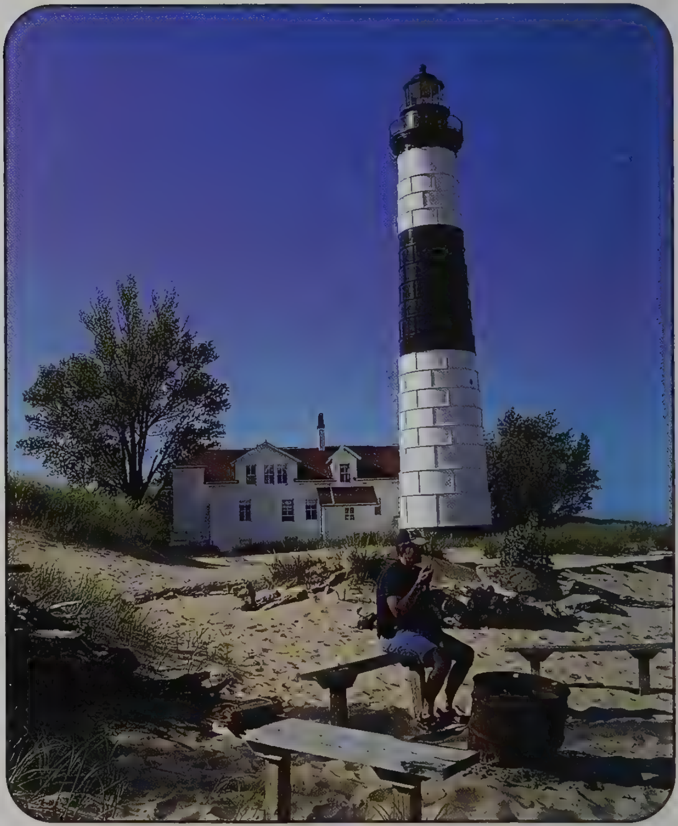

Photo E. Bob, KØNR, making 2-meter FM contacts with a handheld radio at the Big Sable Point Lighthouse. (Photo courtesy of KAØDEH)

By Tomas Hood,* NW7US/AAAØWA

The Science of Predicting VHF-and-Above Radio Conditions

The New World of VHFing

High-frequency radio enthusiasts can hook up a light bulb and communicate with the world, when propagation conditions are "just right." Better yet, just string up some wire, tune it up to a transceiver, and talk around the world.

At least, that's how things work from the perspective of DXers enjoying the worldwide around-the-clock excitement of HF signals propagating when the Sun is popping with flares and peppered with sunspots during the peak years of a solar cycle. However, this cycle is just about at its end, and quiet solar conditions have all but put a wet towel on worldwide around-the-clock HF propagation.

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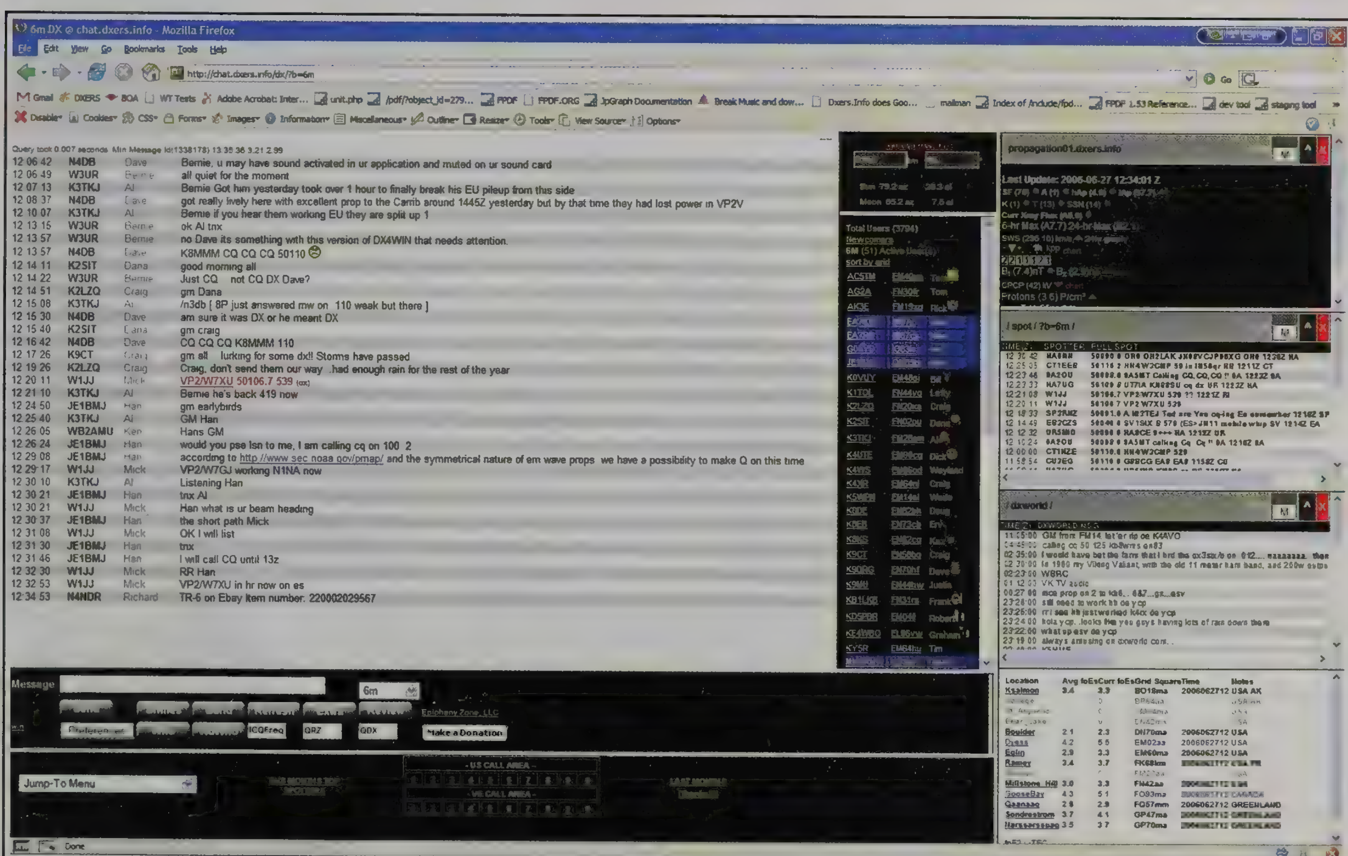
While HF radio DXers long for the coming upswing of the next solar cycle, Cycle 24, rumor has it that the folk on VHF and higher frequencies are out in full force, working "real radio." They cook their meals in front of their portable parabolic dish antenna, while trying to set new distance records. They bounce signals off the moon or off plasmatic meteor trails. Their DX is a raspy-sounding Morse code signal propagated by way of backscatter, aurora, and sporadic-*E*. A VHFer has to have more than a wet noodle or the losses will make the antenna system nothing more than a dummy load (at best, although read about a VHFer who could work a local repeater using a wet T-shirt).

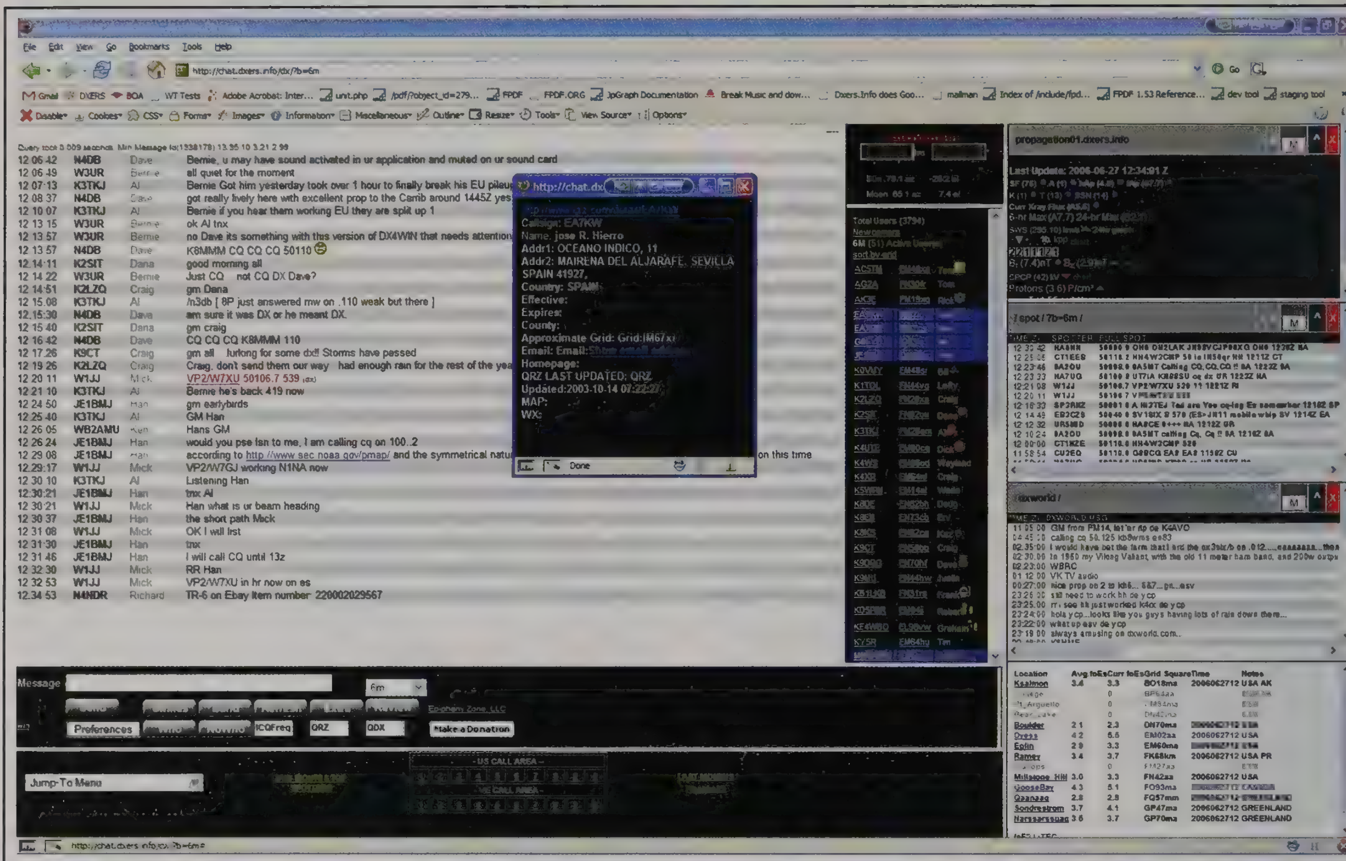
Propagation on VHF and above is not quite the same as it is on HF. Sure, *F*-layer refraction takes place at times on 6 meters and a bit higher, and it is true that sporadic-*E* works on HF, but there is a whole different and exciting set of modes and techniques unique to VHF and up.

Is it possible to predict propagation conditions and DX openings on the frequencies above 30 MHz? Are there reliable models that enable us to forecast sporadic-*E*, aurora, tropospheric ducting, and other known (or unknown) propagation modes?

After many decades of on-air experience, the amateur and scientific communities are still struggling to find a practical understanding of the complex modes of propagation unique to VHF and above. While decades of weak-signal and long-range (DX) operation on VHF exist, most of this historical information is contained in contest and special event logs. More



The live display of 6-meter operators as spotted and mapped at the <http://chat.dxers.info/> site that Tim Havens, NN4DX, provides to the VHF community.



Looking up a callsign of a spotted 6-meter operation on QRZ is as easy as a mouse click. (Image from <http://chat.dxers.info/>)

significantly, most of this historical data is sparse and the number of operators limited. There has been no historical, worldwide data, simply because there hasn't been a large enough population of VHF operators active in weak-signal long-distance DXing. The research done by the scientific community is helpful, but also limited to very specific research. There is a great opportunity for us amateur radio scientists to unlock the secrets of propagation on these higher frequencies.

True worldwide exploration of propagation on the amateur bands above 30 MHz has only recently become a reality. The number of active, on-air amateurs on VHF/UHF has only recently reached a level high enough to support true research of regional, national, and worldwide VHF/UHF DX. A concerted effort is under way to record daily activity worldwide. More accurate DX clusters where grid-square information is recorded for both ends of the QSO, e-mail reflectors and on-line forums for real-time discussion of current conditions, and repositories of logs are all ways we are increasing our knowledge. In addition, detailed geomagnetic and solar data is at our disposal through the internet, as well as real-time monitoring of the ionosphere, weather, and propagation.

An Example of the New World of VHFing

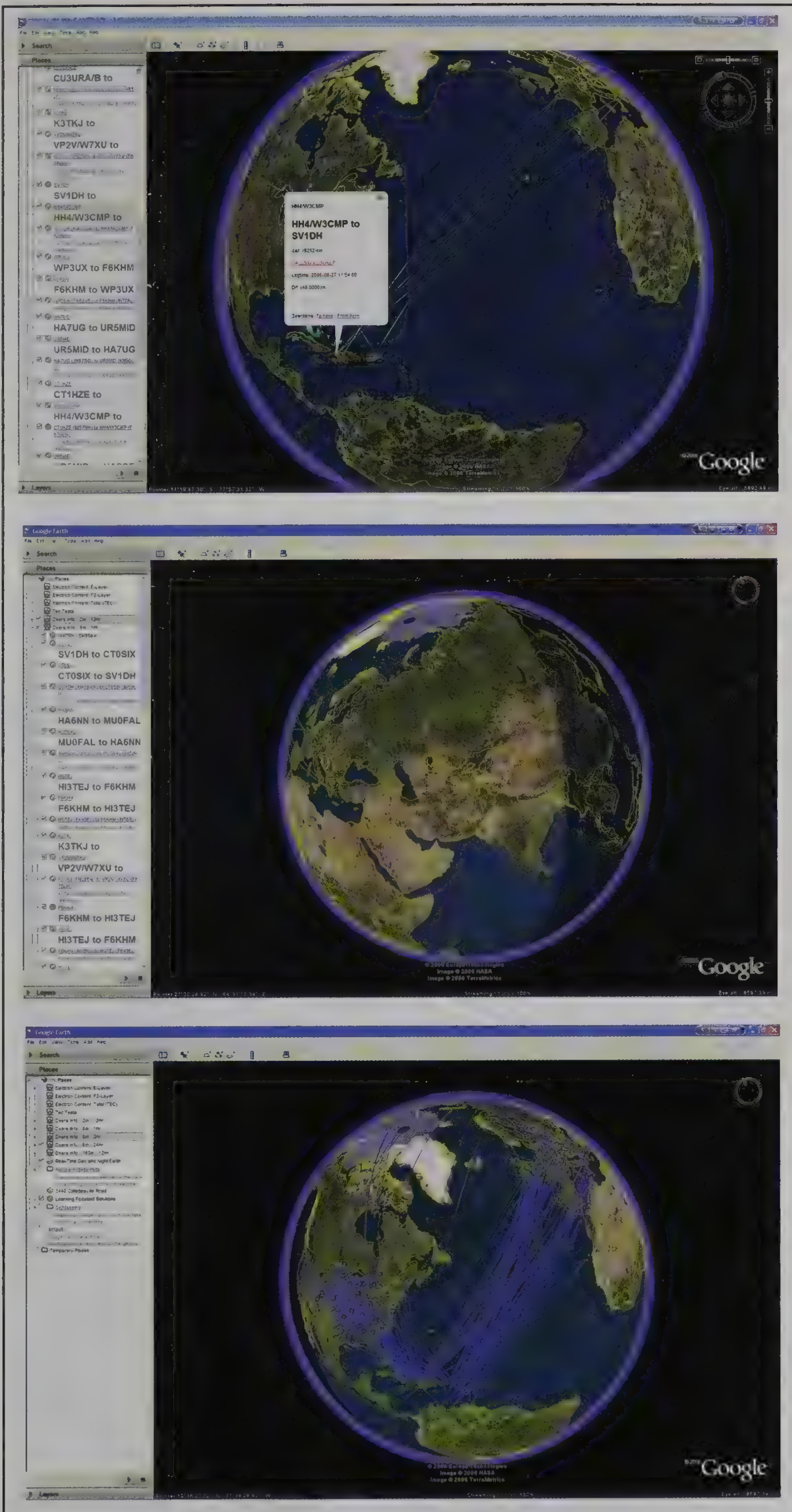
Back in November of 2000, Tim Havens, NN4DX (then N1RZ), living in northern FN44 (Whitefield, NH) started a basic internet chat website that catered to some of the specific needs that very active 50-MHz experts had requested. Along with this functionality and links to other informational websites, Tim provided website tools to calculate Maidenhead Grids from latitude and longitude coordinates and to view calendar dates when the moon would be visible for earth-moon-earth (EME) operations.

When some of the content found on various other websites became stale or unavailable, Tim decided to start getting involved with locating root sources for the data that VHF operators rely on when determining propagation conditions on 50 MHz.

Some of the propagational indicators were so reliable that he was able to provide alert information as to when possible sporadic-*E* (*Es*) might exist, or when auroral conditions were optimal for 50 MHz and above.

In mid-2001 Tim was working for a maps-and-driving-directions company <www.mapblast.com> and got the idea that he could take spotted packet traffic and show their great-circle shortest radio paths by using maps that plot in real-time where the VHF signals were propagating. Today, the maps that Tim's tools create are updated every minute of the day with nearly-real-time data. This most likely was the first web-based map representing DX packet cluster data. The map site is hosted at <http://maps.dxers.info/>.

This site started out as a simple chat website and then evolved into a mapping site which has the ability to allow hams to visualize the live paths as they are occurring and to allow them to make wiser choices as to how they can best take advantage of current conditions. Likewise, many hams have come to know that if nothing is showing on these maps, most likely conditions are quite flat. Many of the world's premiere DXpeditioners stay in close contact with the community found at Tim's site in order to maximize the expeditions' exposure and improve their log book line counts.



Examples of Tim's Google Earth DXers (spot and QSO) plot. (Images courtesy of Google Earth/Tim Haven)

Dxers.info is to the 6-meter operator what the Yagi is to the transceiver. Nowadays in this ever-changing, technologically advanced age, serious 6-meter DXers are using every tool at their disposal to gather and exchange information about possible 6-meter DX paths. More than ever before, rare DX operations "check in" from some remote spot on the globe and learn and talk to the rest of the 6-meter community. Then they go on to make actual QSOs, because they are armed with the knowledge of when and where to look for openings and stations to work. In decades past, many rare or remote HF DX stations tried turning on the 6-meter rig once or twice, but then gave up as they failed to make any contacts, let alone hear any activity (yeah, I am even guilty of that).

Now, due in large part to Tim's project, there are much fewer of those stations failing on 6 meters. Efforts by these operations are succeeding and the operators are becoming among the converted! Also, when there's no propagation on VHF, the community bands together at Tim's site and talk with "the guys" (we need more ladies on the DXing segments above 30 MHz!) about 6 meters and the required equipment. This is crucial to operator skill enhancement and station development.

As Dan O'Connell, WA7TDZ (CN92, Oregon), testifies, "Without a doubt, Tim has created a world-class website that not only encompasses a different real-time chat room for each VHF band, but also a magnificent real-time world map, showing the QSOs currently taking place. This marvelous tool is unprecedented for understanding current conditions, especially for *Es* on 6 meters, but also is especially helpful in forecasting when conditions may be especially good for your location. The ability to actually talk to the DX operator at the same time is especially helpful in 'snagging' that new one."

Recently Fusion Numerics <http://www.fusionnumerics.com/> based in Boulder, Colorado made available a web service which allows Tim's site to be able to query various altitudes around the entire globe for the Total Electron Content at a given altitude. Tim is able to demonstrate this using Google Earth. The results are very interesting at foEs (the maximum ordinary-mode radio frequency that is refracted by a sporadic-*E* cloud in the *E* layer of the ionosphere) and foF2 (the maximum ordinary-mode radio frequency that is refracted by the *F2* layer

of the ionosphere). The results have proven to be powerfully useful in spotting DX openings, especially when the maps plot radio paths that have been reported by packet cluster spotters. Tim's Google Earth (see <http://earth.google.com/>) project site can be viewed at <http://www.dxers.info/google/earth/> along with some helpful tips on its use.

Over the past six years the site has grown to a group of about 3800 registered users. Most of these operators are very active at 50 MHz and above. Many are also active EMEers. Alan Benoit, WQ5W, reports how critical Tim's project has been in his activities:

The 2006 *Es* season opened up very promising, much better than 2005, from here. We had several nice Caribbean openings and even an opening into EA8. However, nothing could have prepared me for the incredible opening to JA the evening of Sunday, June 4.

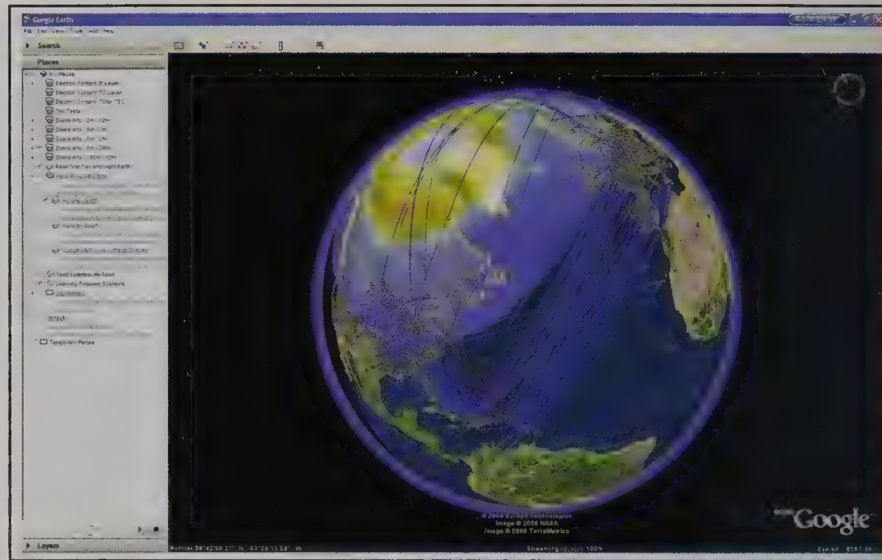
The prelude to the opening was pretty normal. Sunday morning we had a nice stateside opening and EH8BPX was readable for a few hours straight and we had QSOs at 14:46Z and 17:29Z. Several 5's also reported working into CT3 and CT but I couldn't hear them. In the afternoon, the band opened to the Caribbean and I worked FY1FL for a new one at 21:51Z.

What happened next was the most incredible thing I have ever experienced on 6 meters. I was about to shut down the rig and go out for the evening when I checked the DX cluster one final time at around 5:15 PM local (22:00Z). I noticed with interest that NL7Z in Alaska was being worked in west Texas on SSB. I had only worked one KL7 on 6 meters ever before that—and that QSO was after midnight local time—so I had to give a listen to see if I could hear him. Sure enough, he was a solid 5-7 and he responded to my call immediately.

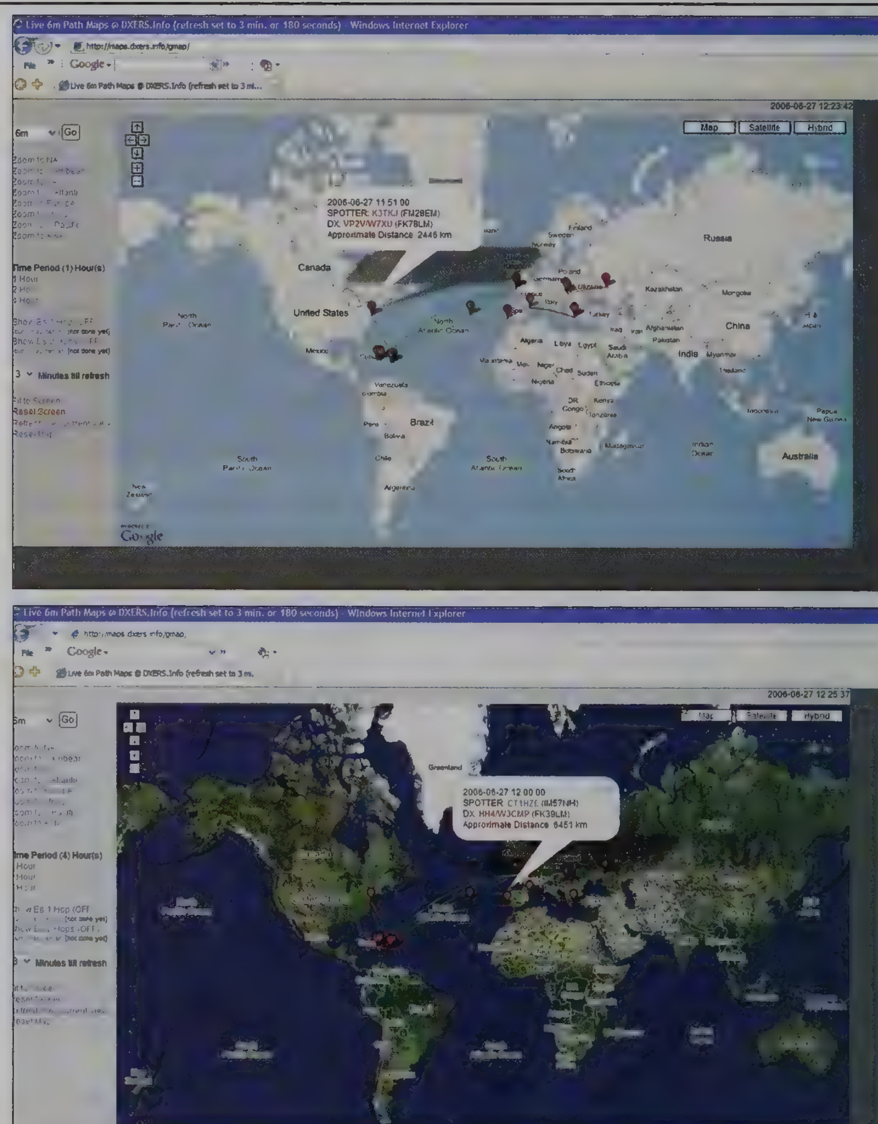
I then saw on [Tim's] 6-meter chat room page <http://chat.dxers.info/?b=6m> that JH2COZ was going to call CQ on 50.096 CW. I had never worked or even heard a JA on 6 meters, so I didn't think much of it, but I figured, "What the heck? I'll listen for a couple of minutes before heading out the door."

So, I tuned to 50.096 and to my amazement there was JH2COZ calling CQ with a solid 559. I gave him a call and he came back immediately and I had worked my first JA ever! I then went up the band and started calling CQ and had many JA's come back to me!

Over the [nearly] next three [and a half] hours I worked 42 JA stations in 10 different grids! The signals were on the weak side in many cases, but all were solid Q5 copy. They were much stronger and more readable than



Example of Tim's Google Earth DXers (spot and QSO) plot showing aurora-mode (AU) activity as well as the auroral oval. (Image courtesy of Google Earth/Tim Haven)



Examples of VHF DX spotting maps with spot information shown in a pop-up box. (Images from <http://maps.dxers.info/>)

the often ESP copy we get on EU stations from here. It felt and sounded very much like the 10-meter JA runs we get in contests at the top of the sunspot cycle. A couple of times during the run I thought it was over, only to have more JA's come back to my CQ's a few minutes later.

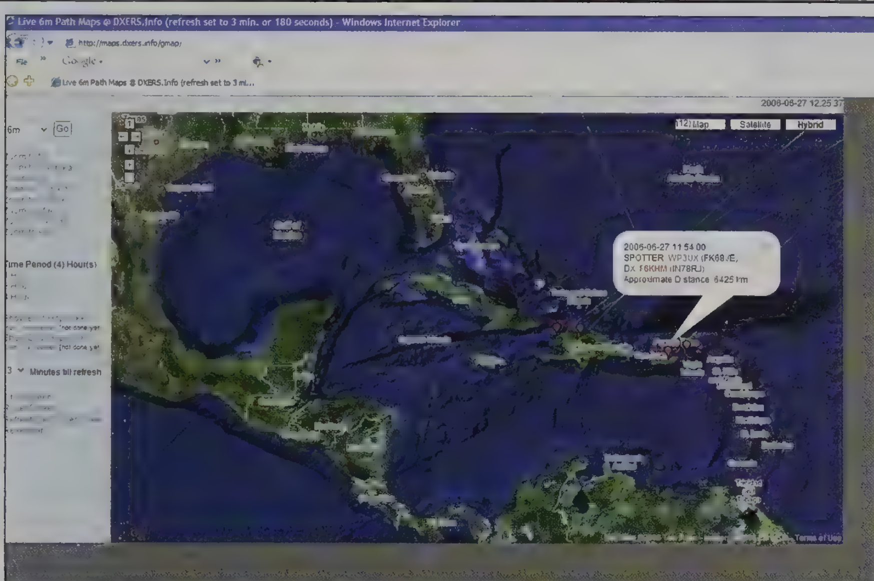
In between the JA's, I also worked KL8DX and several VE7's. I worked my last JA at 01:51Z. It was a great experience sharing the thrill of this opening with the guys in [Tim's] 6-meter chat room. They seemed to be as thrilled and amazed as I was about this. Their encouragement and kind words made the experience even better!

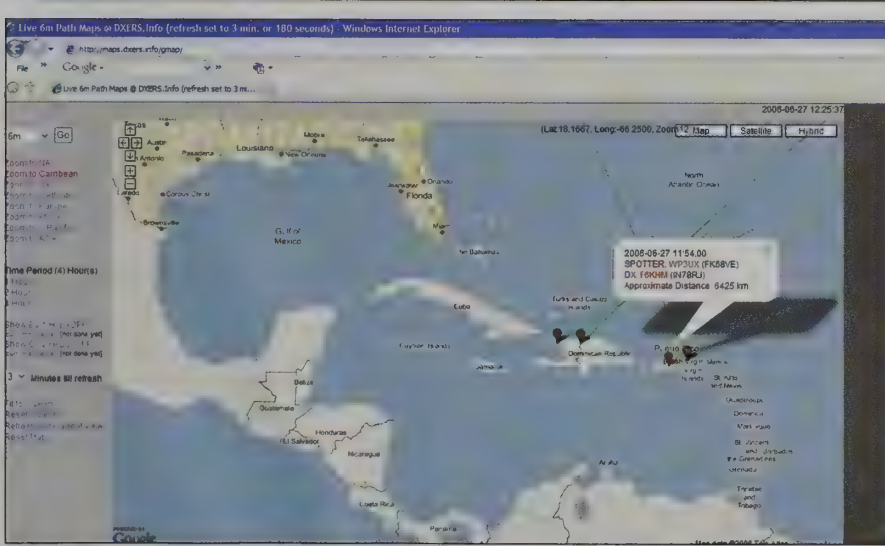
Looking back at my log, the distances worked were between 6166 and 6567 miles. This is incredible considering that at this part of the sunspot cycle and time of the year this had to be sporadic-*E* propagation. This would suggest 4–5 hops of at least 1500 miles on these QSOs. A lot has to go right for this to happen. Some of the more experienced locals tell me that this kind of *Es* opening to JA hasn't happened in Dallas-Fort Worth since the late '70s. I feel very lucky to have been a part of it and won't ever forget it!

As a footnote, the next night there was a JA opening that extended into Arkansas, Oklahoma, Missouri, and Illinois with stations even as far east as Florida working JA. I never heard any signals that night despite constant tuning to the DX spot frequencies. Oh well, no complaining; that's 6 meters!

There are alerts posted in the chat area of Tim's site that draw your attention to things such as spikes in the foEs and foF2 at the global ionosonde sites. (For a basic understanding of what an ionosonde is, refer to <http://www.wdc.rl.ac.uk/ionosondes/ionosonde_basics.html>.) Many of these sites can be seen by clicking on the blue circles of the <http://maps.dxers.info> pages.

Tim's site also reveals that many hams are interested in auroral propagation and monitoring things such as Cross Polar Cap Potential (CPCP) <http://www.dxers.info/reports/prop/cpcp.html>. These tools all are intended to allow you to make educated guesses at what is currently occurring in the ionosphere and to help you make informed choices as to how you can best exploit these conditions to fulfill your DXing desires. Visit Tim's site <http://www.dxers.info/> and see what's new!





Perseid Meteor Shower

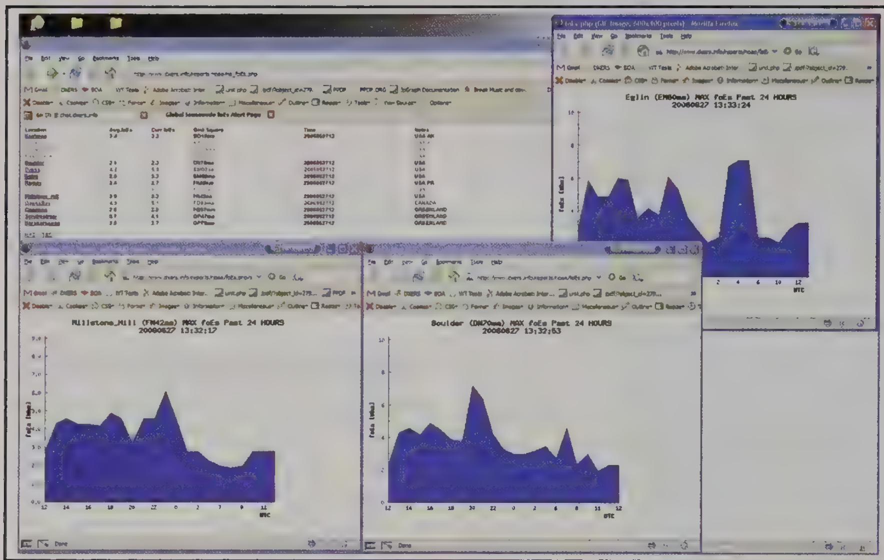
One of the most reliable yearly meteor showers is the *Perseid*. The *Perseid*, like other meteor showers, is named after the constellation from which it first appeared to have come. This shower's constellation is Perseus, which is located near Cassiopeia. *Perseids* favor northern latitudes. Because of the way Comet Swift-Tuttle's orbit is tilted, its dust falls on Earth's Northern Hemisphere. Meteors stream out of the constellation Perseus, which is barely visible south of the equator.

Lewis Swift and Horace Tuttle, Americans working independently, discovered a comet in August 1862. Three years later Giovanni Schiaparelli (of Martian "canali" fame) realized it was the source of the August *Perseid* meteors. The comet, known now as Comet Swift-Tuttle, leaves a trail of dust that Earth passes through during August.

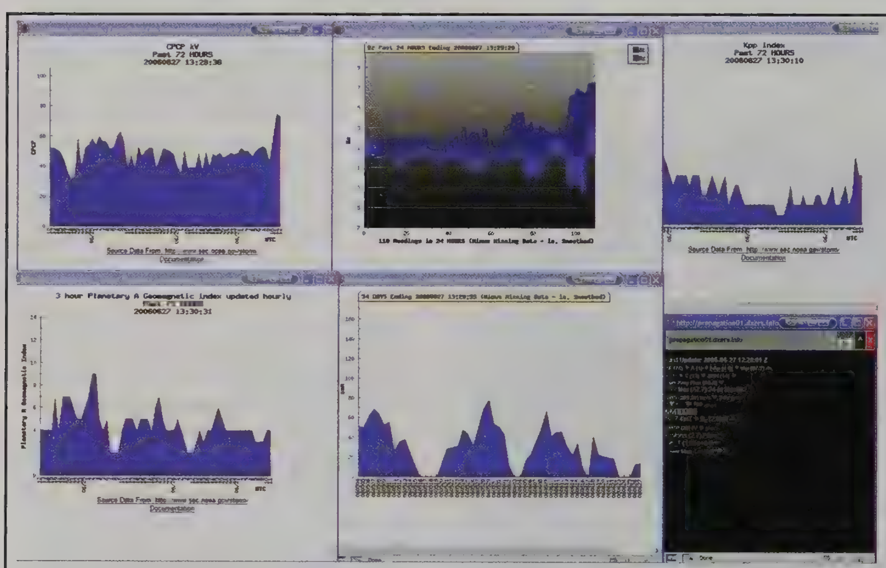
This year, the *Perseids* should peak between 2300 UTC August 12 and 0130 UTC August 13, although other peaks on August 13 are expected at around 0200 UTC and again at 0900 UTC. Simulations made by Peter Brown a few years ago suggest that enhanced *Perseid* activity is possible this year. However, it is not expected to be as strong as the 2004 shower. The number of visual meteors is expected to be about 100 per hour. It is possible, using high-speed CW, to realize a much higher hourly rate, since many meteors that are not visible might contribute to the ionization necessary for long-distance contacts.

The *Perseid* shower begins slowly in mid-July, featuring dust-size meteoroids hitting the atmosphere. As we get closer to August 12, the rate builds. For working VHF/UHF meteor scatter, this could prove to be an exciting event.

The best time for working the *Perseid* VHF/UHF meteor scatter in North America is during the hours before dawn, as early as midnight, but more likely peaking after 2:00 AM until about 5:00 AM local time.



Ionosonde-based charts showing sporadic-E conditions. (Image from <http://maps.dxers.info/>)



Additional propagation charts at Tim's <http://www.dxers.info/> website.

The characteristic *Perseid* burn is bright white or yellow and typically lasts less than a half second. The brighter meteors usually leave a persistent train or "smoke trail" that lasts a second or two after the meteor has vanished. This is not really smoke at all, but rather ionized gas created by the meteor passing through the atmosphere at tremendous velocities. It is this trail that potentially reflects the VHF radio signal.

Other Meteor Showers of Summer

There is very little anticipation of significant *Draconids* activity this year. The *Draconids* is primarily a periodic shower that produced spectacular, brief meteor storms twice in the last century, in 1933 and 1946. Most recently, in 1998, we saw a moderate peak of a ZHR (zenith hourly rate) reaching 700. This was due to the return of the stream's parent comet, 21P/Giacobini-Zinner, returning to perihelion. If there is an outburst of activity, the possible peak timings would span 1430 UTC and 2220 UTC on October 8, to 0407 UTC on October 9, 2006. The *Draconid* meteors are exceptionally slow-moving, a characteristic that helps separate genuine shower meteors from sporadics accidentally lining up with the radiant. This is a good shower to work meteor-scatter mode, since we might see storm-level activity this year.

Meteor activity improves substantially for the *Orionids* later in October. The *Orionids* shower is active from October 2 through November 7, peaking on October 21 at 2000 UTC. The hourly rate could reach about 30 meteors per hour this year. This is expected to increase in the next two years.

For more information, take a look at <http://www.imo.net/book/print/838>. Go to <http://www.meteorscatter.net/metshw.htm> for a very useful resource covering meteor scatter and upcoming showers.

The Solar Cycle Pulse

The observed sunspot numbers from April through June 2006 are 30.2, 22.2, and 13.9. The smoothed sunspot counts for September through December 2005 are 25.9, 25.5, 24.9, and 23.0.

The monthly 10.7-cm (preliminary) numbers from April through June 2006 are 89.0, 81.0, and 80.1. The smoothed 10.7-cm radio flux numbers for September through December 2005 are 87.8, 87.4, 86.7, and 85.4.

The smoothed planetary *A*-index (*Ap*) numbers from September through December 2005 are 11.8, 11.6, 11.1, and 10.4. The monthly readings from April through June 2006 are 11, 8, and 8.

The smoothed monthly sunspot numbers forecast for August through October 2006 are 10.5, 10.3, and 9.1, while the smoothed monthly 10.7 cm is predicted to be 73.7, 72.7, and 71.5 for the same period. Give or take about 12 points for all predictions (that means that the smoothed sunspot figures could be zero for any of these months, since we are now at solar cycle minimum).

(Note that these are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review.)

Feedback, Comments, Observations Solicited!

I am looking forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail, or drop me a letter about your VHF/UHF experiences (sporadic-*E*, meteor scatter?). I'll create summaries and share them with the readership. I look forward to hearing from you. You are welcome to also share your reports at my public forums at <http://hfradio.org/forums/>. Up-to-date propagation information is found at my propagation center, at <http://prop.hfradio.org/> and via cell phone at <http://wap.hfradio.org/>.

Until the next issue, happy weak-signal DXing. 73 de Tomas, NW7US

Six Meters *(from page 7)*

ers. One is at 75 feet and the other is at 40 feet. Interestingly enough, for the majority of QSOs I used the 40-foot antenna, as it produced the best signal-to-noise ratio, due to the fact that signals were equally strong on both antennas, but the 40-foot antenna was quieter. However, as the opening closed, the antenna at 75 feet was the best, as signals disappeared from the 40-foot antenna. *(Editor's note: Alan uses a Kenwood TS-2000 plus a Commander VHF1200 amp at 1 KW.)*

Looking back at my log, the distances worked were between 6166 and 6567 miles. This is incredible, considering that at this part of the sunspot cycle and time of the year this had to be sporadic-*Es* propagation. This would suggest 4–5 hops of at least 1500 miles on these QSOs. A lot has to go right for this to happen. Some of the more experienced locals tell me that this kind of *E* opening to JA hasn't happened in Dallas-Fort Worth since the late '70s. I feel very lucky to have been a part of it and won't ever forget it!

As a footnote, the next night there was a JA opening that extended into Arkansas, Oklahoma, Missouri, and Illinois with stations even as far east as Florida working JA. I never heard any signals that night despite constant tuning to the DX spot frequencies. Oh well, no complaining. That's 6 meters!

All told, Alan worked 42 Japanese stations via CW over a period of three hours and 24 minutes. Distances ranged from 6166 to 6500 miles. He worked the JA1, JA2, JA3, JA7, JA9, and JAØ call areas, covering the following grids: PM84, PM85, PM86, PM94, PM95, PM96, PM97, QM05, QM08, and QM09. Another Texas station that worked into Japan on June 4th was K5RLA, Carla Dyer, who used 100 watts into a 6M7JHV antenna at 50 feet to work (beginning at 2325 UTC) JHØRNN, followed by JA7QVI and JA7SJI.

This opening was not confined to just Texas, as Jon Jones, NØJK, in Kansas managed to get in on the action. His job required him to work on the weekend, so during breaks he set up a homemade two-element Yagi on a mast that connected to the radio in his car while parked on the top part of a parking garage. Jon had a break late in the day on the 4th, and at 2341 UTC on 50.100.6 MHz he worked JA7QVI (QM08) on CW; 559 reports were exchanged both ways. Jon notes that he probably would not have been able to make the QSO with a vertical roof-mounted antenna on his car and that the portable beam design that he used (using plans from the book *Six Meters, A Guide to the Magic Band,* by WB2AMU and available from Worldradio books), gave him enough punch to complete the contact (photos B and C).

A number of operators have to rely on portable and mobile setups in order to operate on 6 meters because of work situations or antenna restrictions in their area. The 6-meter band is great for these hams! It does help, though, when one station in a long-range QSO has a super antenna setup such as that of JA7QVI.

There was be even more activity the next day, with another U.S. to Japan opening on 6. This time veteran 6-meter operator Rick Roderick, K5UR, from Arkansas was involved. Rick had worked some of the JA stations the day before, so he was on the lookout for more of the same. This time Rick worked over 130

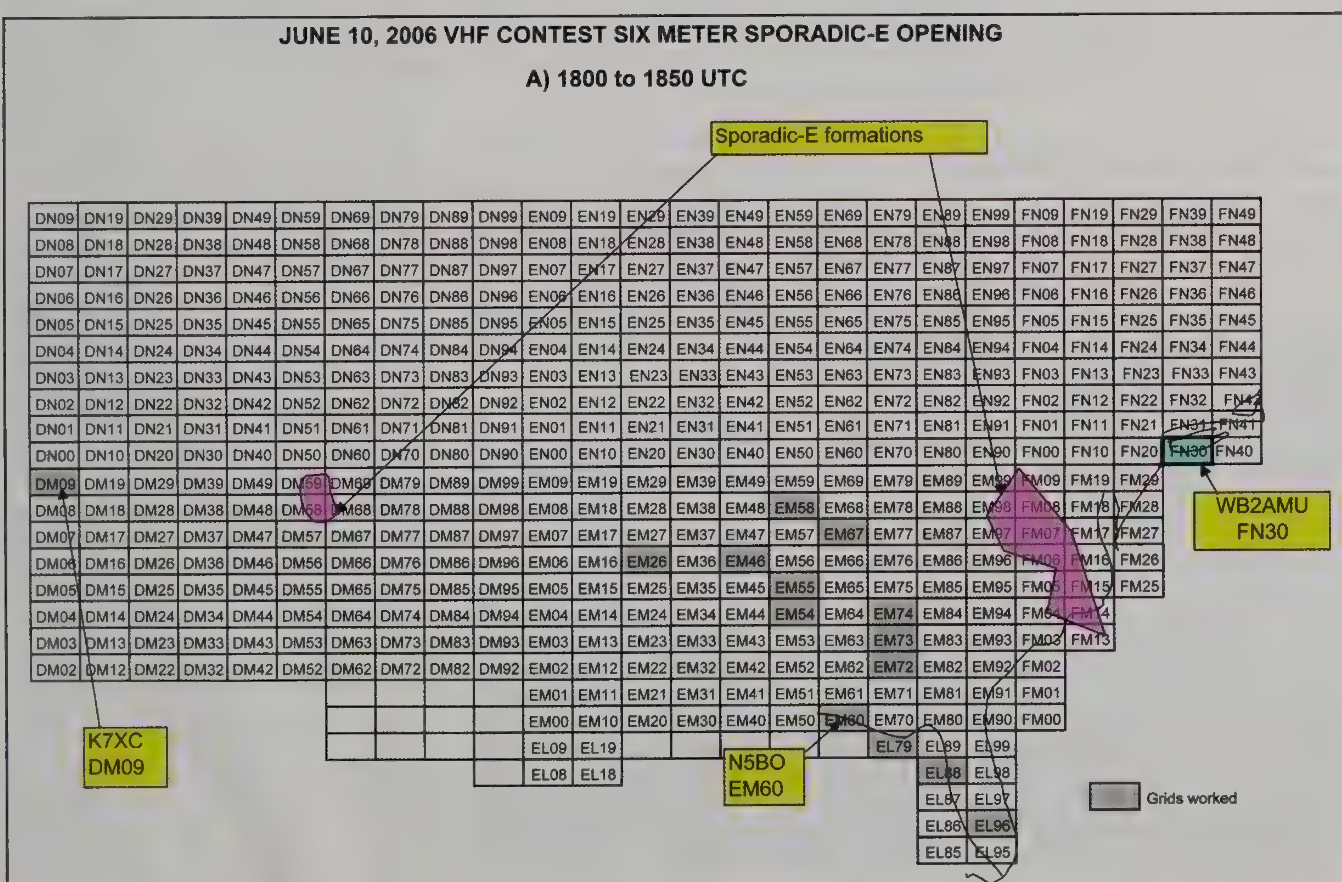


*Figure 2A. This is the opening hour of the ARRL June VHF Contest. Using the midpoint method, a rough mapping of the sporadic-*E *formations can be created. N5BO is highlighted on this map for reasons that will be seen in the next figures, where the conditions change when the formations move north.*

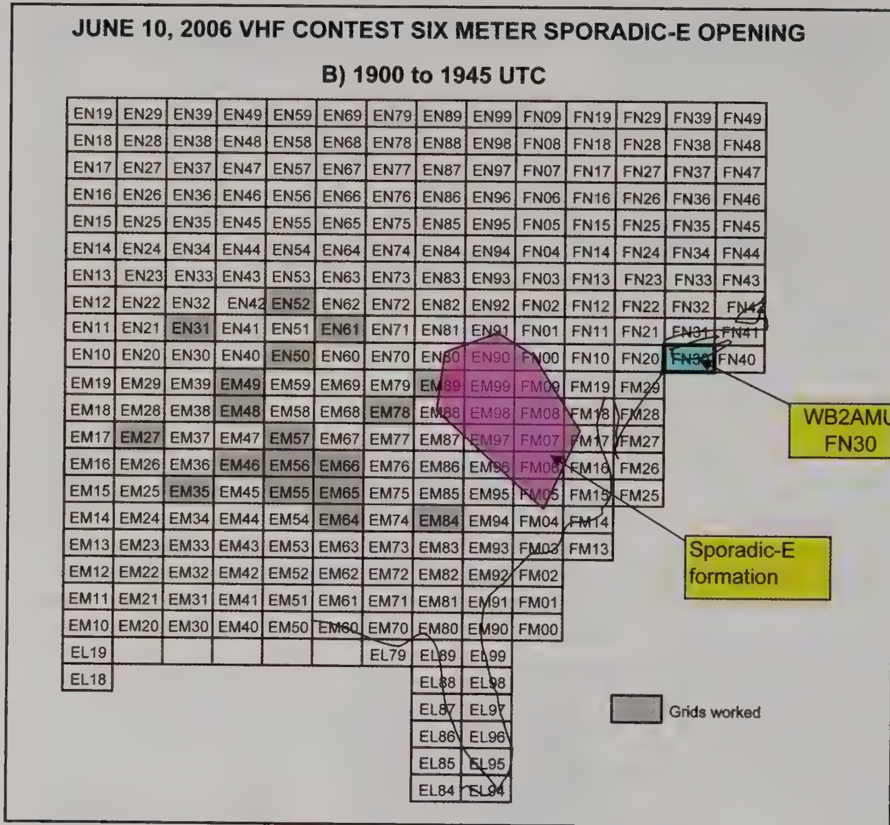


*Figure 2B. Here the sporadic-*E *formation in the east has moved northward, causing the loss of conditions between the southern tier stations and the northeast U.S. The western sporadic-*E *formation has dropped out but will reappear shortly.*

JA's in a solid run for almost two hours (from 2353 UTC, June 5 to 0145 UTC, June 6). His first JA was JA9LSZ, and many of the subsequent stations were loud (over S9). Rick noted that the pile-up was huge. He could have worked split frequency if he had wanted to, as at times there were so many stations calling.

EU to NA Openings

In the summers of 2004 and 2005, transatlantic 6-meter QSOs were not too plentiful, even in the northern tier states of the U.S. and northeast Canada. June 2006 saw a welcomed change in this trend.

Throughout the month of June there were openings between Europe and North America. One opening occurred on June 9th, when Pat Rose, W5OZI, in Texas worked into western Europe and had QSOs with G3WZT, ON4IQ, CT1HZE, and EA7KW. K5RLA worked ON4IQ on June 9th as well.

Another interesting opening took place on June 12th at 1200 UTC, when Bob Billings, VE1YX, worked a string of 30 western European stations in the UK, Italy, and a few in Hungary in a period of 20 minutes on SSB 50.115 MHz! It appeared that this would be a better summer for transatlantic sporadic-*E*.

One thing that seems to be consistent is a number of these openings appear to be narrow in scope. For example, when VE1YX works into Europe, Lefty Clement, K1TOL, in Maine (grid FN44) does not always hear Europe at the same time, and vice versa.

June VHF Contest Report

The 2006 ARRL June VHF Contest was the weekend of the 10th and 11th. With June VHF contests we always hope for a major sporadic-*E* opening to increase the number of stations that can be worked, in addition to those that are worked by line-of-sight. For the past few years, the June event has predominantly been a line-of-sight affair for many in the U.S. and Canada, with occasional one-hour sporadic-*E* openings. In June 2005, there was a major aurora opening for the last part of the contest, and it covered much of the northern U.S. and Canada.

Every once in a while, you have that dream opening on 6 meters during a major contest. In the past, I actually had a few good sporadic-*E* openings that occurred during the VHF contest, but for the most part these openings tended to be of short duration and maybe a handful of stations were worked. Prior to June 2006, the last great June VHF contest opening that I had was during the first two hours of the June 1991 event.

Prior to the beginning of the 2006 contest, I worked a station in Missouri while mobile. I thought that at least there was the possibility of a decent sporadic-*E* opening during the contest.

I operate in the QRP portable category, and I go to the nearest hill here on Long Island. It is 250 feet high with good line-of-sight in all directions. It took about ten minutes to set up a three-element Yagi on a mast at 10 feet in an umbrella stand with a Yaesu FT-690 hooked to a portable battery. I could not set up the antenna any higher, since it was very windy. With about three minutes to spare, I could hear that there were already some strong signals breaking through on 6 meters.

When the contest began at 1800 UTC, there was bedlam on 6 meters. Activity extended from the bottom of the band all the way up to 50.310 MHz! I used the two VFOs on the FT-690, with one set in the SSB portion and the other in the CW portion of the band. I was constantly switching between the two VFOs, because as a QRP operator, I knew that I could not hold a frequency, so I had to resort to search-and-pounce tactics.

I was having very good success running CW and surprisingly also SSB, particular in the 50.200–50.300 MHz range. Double-hop sporadic-*E* was coming in, and I picked up Tim, K7XC, in DM09 on CW 20 minutes into the contest! For the first hour I worked many different grid squares at a good clip, initially into the EM and EL grid fields. By the second hour, I was working EM and EN grid fields.

I fully expected the opening to fade after an hour or so, but surprisingly it kept going for several hours. During the second hour (1900 UTC), I ran a string of 33 stations, which is a very good rate for a QRP station. At two hours into the contest I worked three stations consecutively via double-hop sporadic-*E*: W7GJ (DN27), VE5ZX (DO62), and VE5UF (DO61). It was truly amazing how my puny 10-watt signal broke the pile-up of two-land stations on W7GJ, Lance Collister. I realized that I had no hope of breaking the pile-up on SSB, so I used a standard QRPer technique of calling Lance on CW. On the second shot Lance said, "Who is that station on CW?" Then

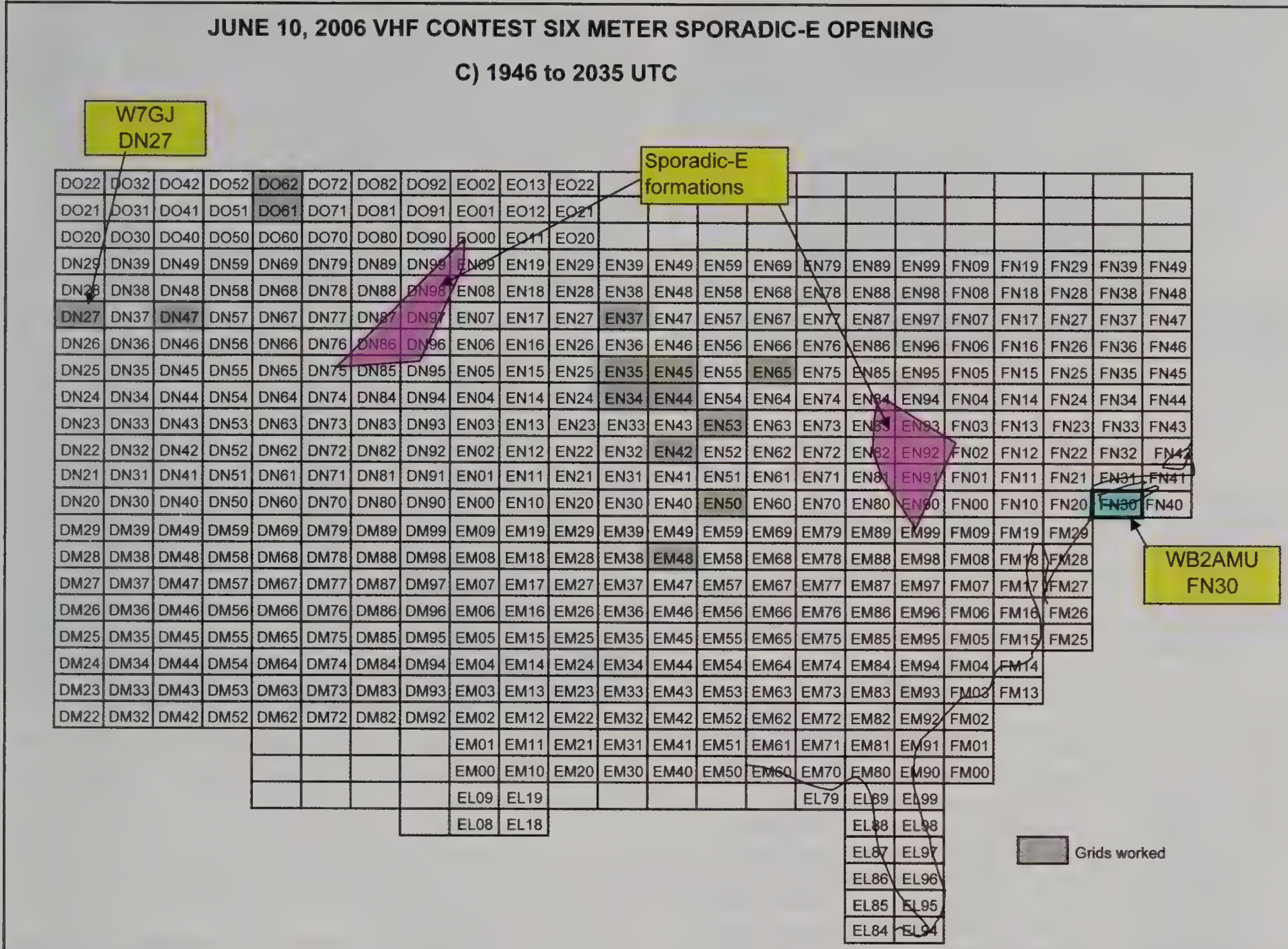


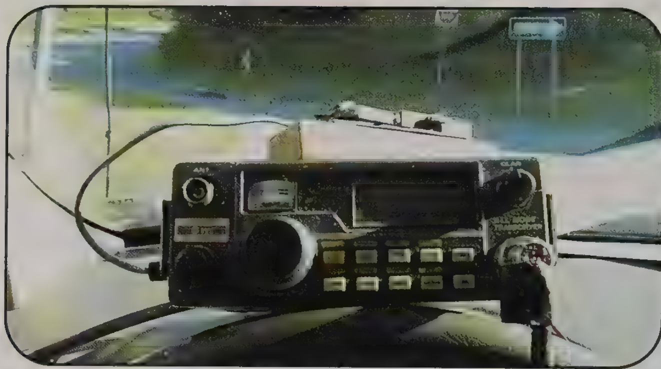
*Figure 2C. About two hours into the contest both active sporadic-*E *formations in the U.S. have continued to move toward the north, and by this time stations in Montana can be worked by WB2AMU. In another hour WB2AMU is able to work double-hop into the CN grid field in the state of Washington running QRP!*

I came back and he worked me, despite the fact that there were kilowatt stations calling him on SSB!

Lance wrote to me after the contest: "Yes, many thanks for calling on CW! You couldn't believe the QRM! I have never had a double-hop opening like that in my 10 years on 6 meters. Often I could get only one or two letters of a call. I was amazed how strong the stations actually were when they were calling one at a time! Even stations I could barely discern through the QRM were S9 when everyone else stood by!"

I also worked another station in Montana via two-way SSB—K7BG in DN47. Unfortunately, I missed K7USB in DN17 at around the same time. I have never heard so many stations on 6 meters in my life, except for Field Day 1998. There were between five and ten stations at a time on CW in the CW portion of the band and the QRM was incredible, making it

The three-element MFJ Yagi that WB2AMU used during the June VHF contest from his portable location on Bald Hill in Farmingville, Long Island. He could only get the antenna up 10 feet in the air on that Saturday, because the winds were very strong.



The FT-690 six-meter radio that WB2AMU used in the contest. The radio has 10 watts output, but that did not seem to be an issue with the good openings that were present.

hard to copy some stations, particularly if there was QSB on the signal. I worked stations as high in the band as 50.310 MHz, for example N4JH.

There were also a lot of rover stations in the 4-land call area that were ready to be worked! One station that I worked from EM73 was AF4OD, Bill Capps, and he reported the following:

> I was running behind on my planned schedule for the contest. I left home about 2 hours late. I was busy trying to get transverters for 903 and 1296 running. I'm not a super technician; I can hook up some wires and hope for the best. I left my QTH here in Auburn, Alabama (EM72)and was planning to drive all the way to Tennessee to grids EM65 and EM75 to begin the contest there. During the entire drive north I monitored 6 meters and the band was full of stations.
>
> Since I was behind schedule, I located a large field beside a manufacturing plant in EM73 just 10 minutes prior to the contest. I pulled into the field and used my KU4AB loop on the back of my Suburban to work around 60 QSOs in the first hour. I was CQing around 50.225. There were lots of people calling. After about an hour, I noticed a slowdown in QSOs, so I quickly drove to another grid, EM63, which was about 10 minutes away, and made some more QSOs. I'm still learning how to be a rover station, as I can't seem to get all the QSOs and multipliers that other rovers get. My score was in the 31,000 area, with about 225 QSOs overall and I forget how many multipliers I worked.

After the contest, Justin Fountain, N5BO, from EM60 in Florida, reported to me that he had solid signals for the first hour of the contest, and then there was minimal sporadic-*E* activity on 6 meters for the next several hours. Indeed, from both Justin's and Bill's reports, and as shown in figures 2A, B, and C (covering the first three hours of the contest), the sporadic-*E* formation located in the eastern U.S. was moving northward, and both N5BO and AD4OD would lose out on a lot of the skip QSOs. It is also noted that the western sporadic-*Es* formation was in and out, and it too was moving northward.

I had to take a short break to run an errand, and when I came back to the hill at 2200 UTC, the band was still open, this time to the EN, DN, and CN grid fields. The two sporadic-*E* formations that were in play before were continuing to move northward. I worked WDØT (DN94), K7RAT (CN85), and NU7J (CN88) via double-hop using CW.

Here are some statistics from my perspective to show the depth of the opening. Of the 80 or so contacts I made during the first four hours of the contest, 43 were above 50.200 MHz and another 23 were made in the CW portion, below 50.100 MHz. Less than 20 QSOs were made by me between 50.125 MHz and 50.200 MHz! It was just too crowded and noisy!

Photo C. This is the antenna setup of JA7QVI, who was on the other side of many QSOs on 6 meters during the June 4th opening. It's quite a setup! (Photo courtesy of JA7QVI)

By 2330 UTC the band had quieted down. It was a blur to me, and I just looked for the strongest signal in the clear and often could work that station.

The next day I returned to the hill at 6 AM local time to try to work local grids via the four bands that I had. Six meters opened to eastern Canada by 1400 UTC, and I picked up more new grids that I needed. The band died by 1500 UTC. Later it opened to the south, and I picked up seven more grids I needed in the EL, FM, and EM fields.

In the contest I worked over 110 QSOs on 6 meters, covering 74 grids! I picked up some valuable multipliers on 2 meters, 220 MHz, and 432 MHz as well, making this my best portable QRP effort ever!

This particular contest seemed to be very good for the portable QRP station category. Indeed, signals were so strong that power did not seem to be much of an issue a good deal of the time. One QRP operator I know is Art, N2AU, who runs 5 watts. He worked 75 QSOs on 6 meters, covering 60 grids. Of course, there were many super-stations that made over 500 QSOs on 6, with more than 100 grids worked.

Another QRPer who provided input for this article is Curt Roseman, K9AKS, located in the Midwest. The Midwest received the benefit of skip in two directions—toward the west and toward the east. Curt ran QRP with 10 watts to a five-element Yagi about 7 feet off the ground. He almost worked VUCC on 6 meters, with 98 grids worked. The openings were good for him, because they were widespread geographically, allowing him to maximize the number of grids worked. He noted that the name of the game in a multi-band QRP operation is to work as many grids as possible on 6 meters and spend time getting contacts on the higher bands where they count more. Curt also noted that at least two stations in the Midwest made over 1000 QSOs

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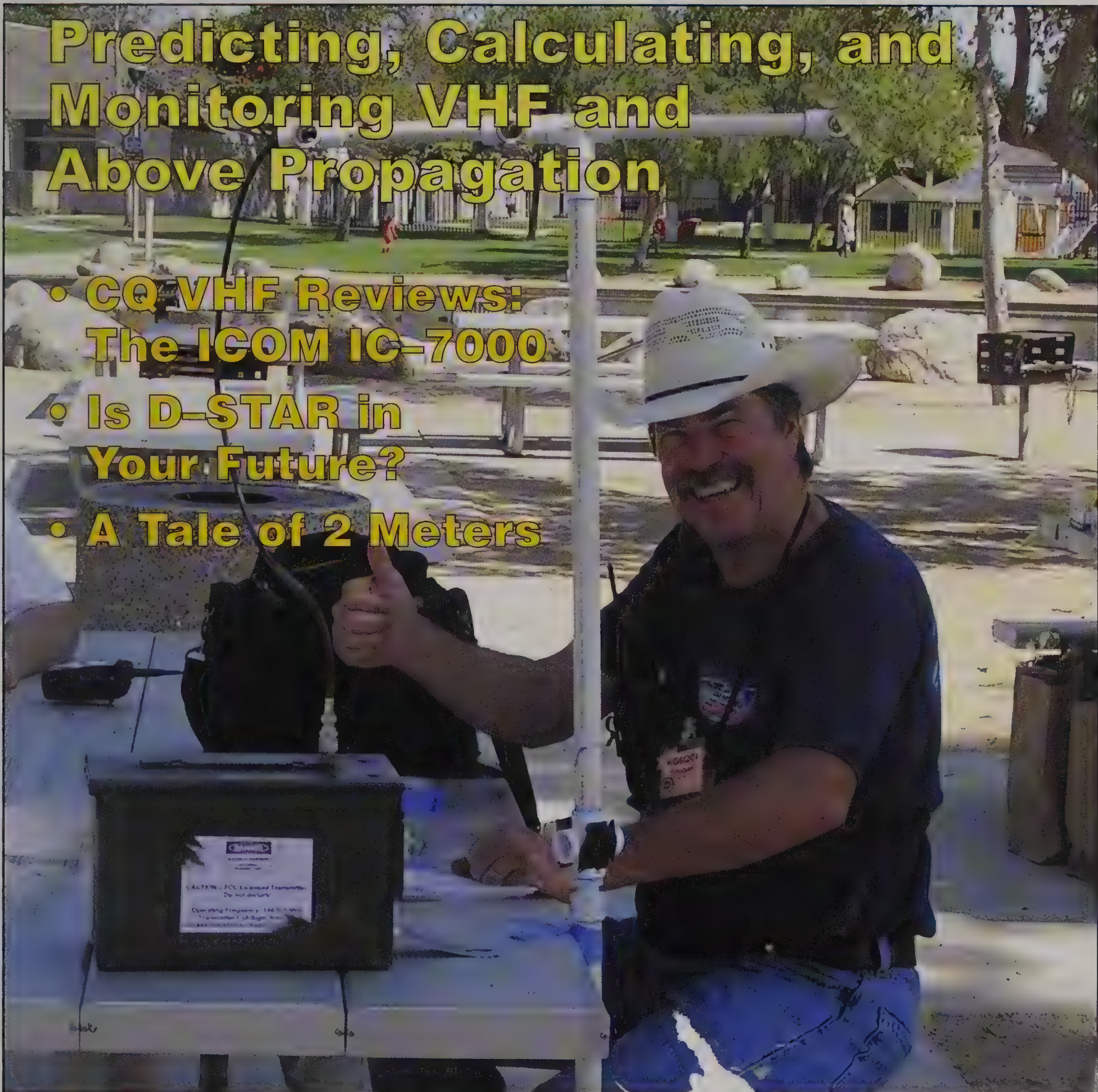

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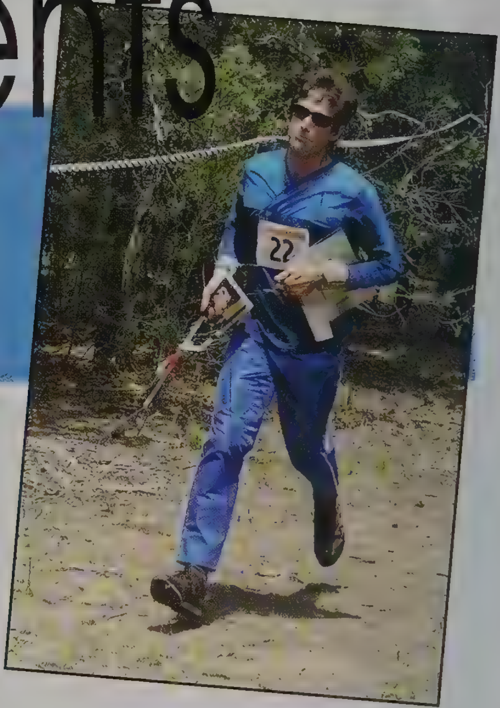

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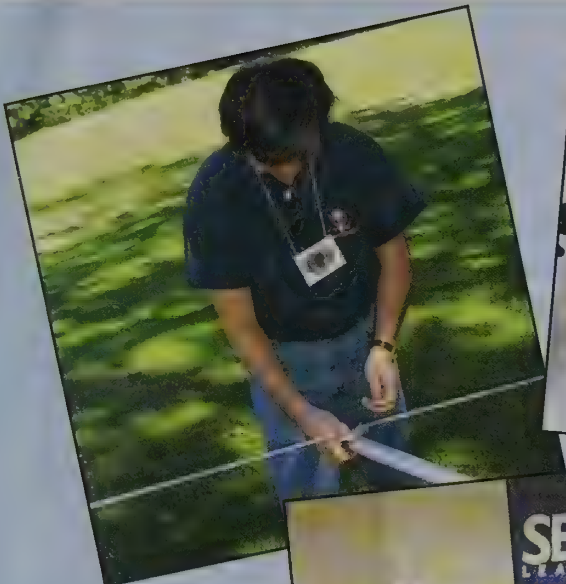
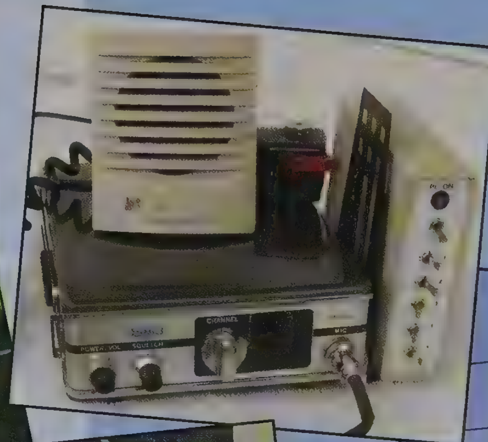
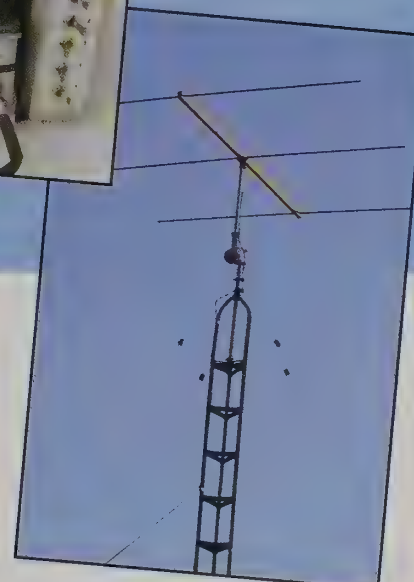






COLUMNS

DEPARTMENTS

On The Cover: Dave Seroski, KG6QCI, is a regular on the South Orange Amateur Radio Association's mobile T-hunts. In 2005 he tracked down a spurious 2-meter signal in Lake Forest, California during a hunt. For details, see the "Homing In" column on p. 36. *(Photo by Joe Moell, KØOV)*

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

Has It Really Been Four Years?

It was four years ago this past January when I met with Dick Ross, K2MGA, CQ Communications owner and publisher, at CQ headquarters in New York to discuss bringing back *CQ VHF* as a quarterly publication. On my return trip to Tulsa, Oklahoma, I was hanging around the car rental agency in New York waiting for my ride to the airport when my cell phone rang. It was Kent Britain, WA5VJB, who asked me about rumors that he had heard about this magazine being published again.

A bit shocked by Kent's "out of the blue" phone call, I asked him where he had heard the rumors and why he was calling me about them. He replied vaguely about the source of the rumors, and then he told me that because I was the editor of *CQ* magazine's VHF column, I should have known about them.

I then replied that the rumors were true and I had accepted the position as editor. Then I asked Kent if he would consider writing a column on antennas for *CQ VHF*, and he said yes. Then and there I had my first columnist. (It is important to note that both Gordon West, WB6NOA, and Ken Neubeck, WB2AMU, agreed to be feature editors as soon as they learned that I was to be the editor.) It was from that beginning of a few regular writers, along with some seed articles from *CQ* magazine, that we have come to where *CQ VHF* is today, four years later.

A look at the masthead in this issue will reveal that we now have more than a dozen columnists, each writing about his or her particular specialty in our niche of the hobby. The significant crossover among the specialties continues to amaze me as well. This crossover is good for all of us, because we learn from one another how to adapt and improve our particular area of interest by way of the previously traveled learning curves of our colleagues.

This crossing over, or cross pollinating, is the key to the future of our hobby on these VHF and above frequencies. Granted, our hobby is comprised of both the HF and VHF spectrums. However, what can be done on HF is limited by spectrum space and FCC and international regulations. On our VHF and above frequencies there are virtually no limits for us—and thus no limits on our experimentation on these frequencies.

Regarding coverage of specialty areas in *CQ VHF*, I would like to add columnists who will provide material on EME activities, ATV, ballooning, DSP, and SDR, as well as Echolink and VoIP. If one of these is your specialty or you know of someone who could write about these topics on a regular basis, please contact me via e-mail at <n6cl@sbcglobal.net>.

Now that we have looked both back and forward, let's take a look at what we have in this issue. I'm sure you will be delighted with the variety of material and the controversial aspect of some of the topics. Let's begin with the controversial.

Controversial Conclusions

For decades, the differences of opinion over the cause of sporadic-*E* propagation have generated considerable discussion and many articles. Even myself and features editor Ken Neubeck, WB2AMU, take opposite positions as to the cause. (I am a proponent of lightning, and Ken is an opponent.) In this issue of *CQ VHF* Bob Gyde, ZL3NE/1, presents a strong case for weather as the cause of many different forms of propagation, including sporadic-*E*. His article begins on page 12.

Complementing Gyde's article is another paper by Rex Moncur, VK7MO, on the appropriate way to calculate tropospheric scatter losses. Rex's paper was originally presented at GippsTech 2005, the annual Australian conference designed to encourage participation in VHF, UHF, and microwave amateur radio operations. His article begins on page 14.

In addition to these articles on propagation, features editor Gordon West, WB6NOA, gives us insight into monitoring 10-GHz beacons using DSP. His article begins on page 16.

ICOM Insights

Last year ICOM rolled out several new products that hold great promise for those of us who favor the VHF and above frequencies. One is a standalone radio and the other is a whole system. The standalone radio, the IC-7000, is essentially a mobile equivalent of ICOM's upscale radios. Steve Hicks, N5AQ, takes the cover off this new radio, gives us a report on it, and suggests a modification to reclaim a previously advertised but later dropped feature—receiving commercial TV stations. His article begins on page 9.

The whole system, D-STAR, is just beginning to make inroads on our bands. Some of us may be put off by its newness and unknown features. However, FM columnist Bob Witte, KØNR, unpacks the mysteries of the system and encourages all of us to take a good look at the benefits it offers. His column begins on page 42.

Hinterland HSMM

One of the definitions of *hinterland* is a region remote from urban areas. John Champa, K8OCL, uses a hybrid of the word hinterland to come up with a new word, Hinternet. Perhaps its use of the 5.6-GHz band might explain its remoteness on our spectrum. However, John explains, "The Hinternet under development by many individuals and groups is intended to eventually become the ham radio digital WANs (wide area networks) formed by the linking of numerous local HSMM nodes or LANs." You see, it's not so remote after all. His explanation begins on page 31.

Capitalizing on the Classics

Borrowing from the classics, authors Dave Holdeman, N9XU, and Malcolm Mallette, WA9BVS, created titles for their articles. Dave borrowed from Charles Dickens' classic *A Tale of Two Cities* to create the title of his article about two classic 2-meter radios. In it he tells the tale of how he once owned one of the radios for all of two weeks (lots of twos in this article), and how he was able to procure a second nearly identical radio on May 2 (see, I told you lots of twos), 2004, thirty years later. Obviously not in new, fresh-out-of-the-box shape, it needed some loving care. Dave begins his story of restoration and reclamation of memories on page 28.

Malcolm borrowed the Sherlock Holmes character from Sir Arthur Conan Doyle to introduce us to an updated version of his transmitter characteristic detection software, called Sherlock. His article begins on page 61.

In the Next Issue

We have more articles in queue for the next issue of *CQ VHF*. Perhaps one of them could be yours. If so, we look forward to hearing from you.

Until next time . . . 73 de Joe, N6CL

A Low-Loss, Low-Cost, Three-Element Yagi Antenna System for 6 Meters

Take a little junk and a trip to the hardware store, add ingenuity, and what do you have? For K8VBL, the result was an antenna system for 6 meters for under $20.

By Tom Turner,* K8VBL/VP2VEL

For a cost of less than $20, a low-loss, three-element Yagi beam antenna can be built for 6 meters using components from local building and auto discount stores. Over 6 dBd gain can be realized, and the beam is light enough to be supported on a salvaged TV antenna tower and rotor. The following is a description of the 6-meter beam, tower, and rotor put up at K8VBL/KA8EHE.

Over the years, many 6-meter beams have been described in ham publications. Most of them use elements of 1/2-inch aluminum tubing. In a quest for materials to build a beam, a metals supply house was contacted and $60 for three 10-foot lengths of 1/2-inch aluminum tubing was the quoted price!

The high cost of aluminum prompted a search for less costly, locally obtainable element material. Our local building-supply discount store offered 1/2-inch (ID) thin-wall copper water pipe for less than $3 per 10-foot length. The advantages of copper over aluminum are that it is a better conductor and is easily soldered to provide low-resistance connections. Copper pipe is somewhat heavier than aluminum but appears to have about the same mechanical strength.

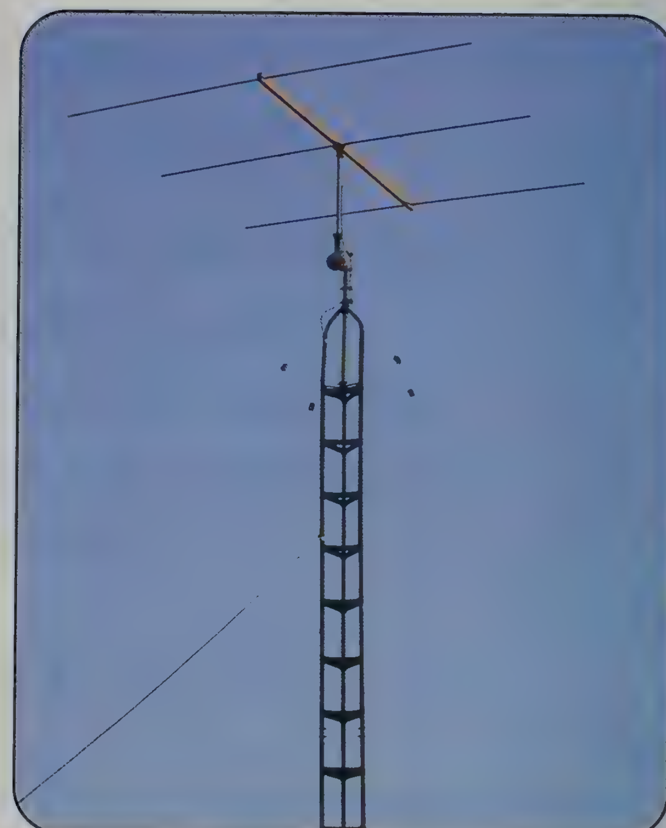
A gamma-matched coax feedline to the driven element was considered but was discarded in favor of a delta-matched ladder-type feedline for the following reasons. A gamma requires several connections, some of which are at low impedance points in the antenna system. Therefore, a few ohms of resistance in these connections will result in losses that seriously degrade the beam's performance.

A delta-matched ladder line requires only two connections, both at points on the driven element where its radiation resistance is relatively high, and provides a fully balanced feed to the driven element to minimize distortion of the beam's directive pattern.

Ladder line has 50% lower loss than coaxial cable at about one third the cost of coax. However, ladder line has the disadvantage of requiring extra care in installation, but by use of an ordinary TV-type lead-in bushing and standoff insulators, a completely satisfactory feedline installation is easily accomplished.

In summary, the completed three-element 6-meter beam has high-conductivity elements, and a balanced high-impedance feed system that provides low loss at low cost (figure 1).

*Apple Hill Farm, 8530 N. Branch Rd., Watervliet, MI 49098



The low-loss, three-element Yagi antenna for 6 meters. (Photos by John Chandler)

A standard three-element Yagi design calls for a resonant driven element, with reflector 5% longer and director 5% shorter, each parasitic element spaced 0.2 wavelengths from the driven element. Element spacing is not critical. Due to the higher conductivity of copper, element lengths are slightly longer than standard designs that employ aluminum elements of the same diameter.

Construction of the Beam

Cut three 10-foot lengths of schedule "M" 1/2-inch thin-wall copper water pipe (5/8 inch OD) to length with a hack saw. (Use

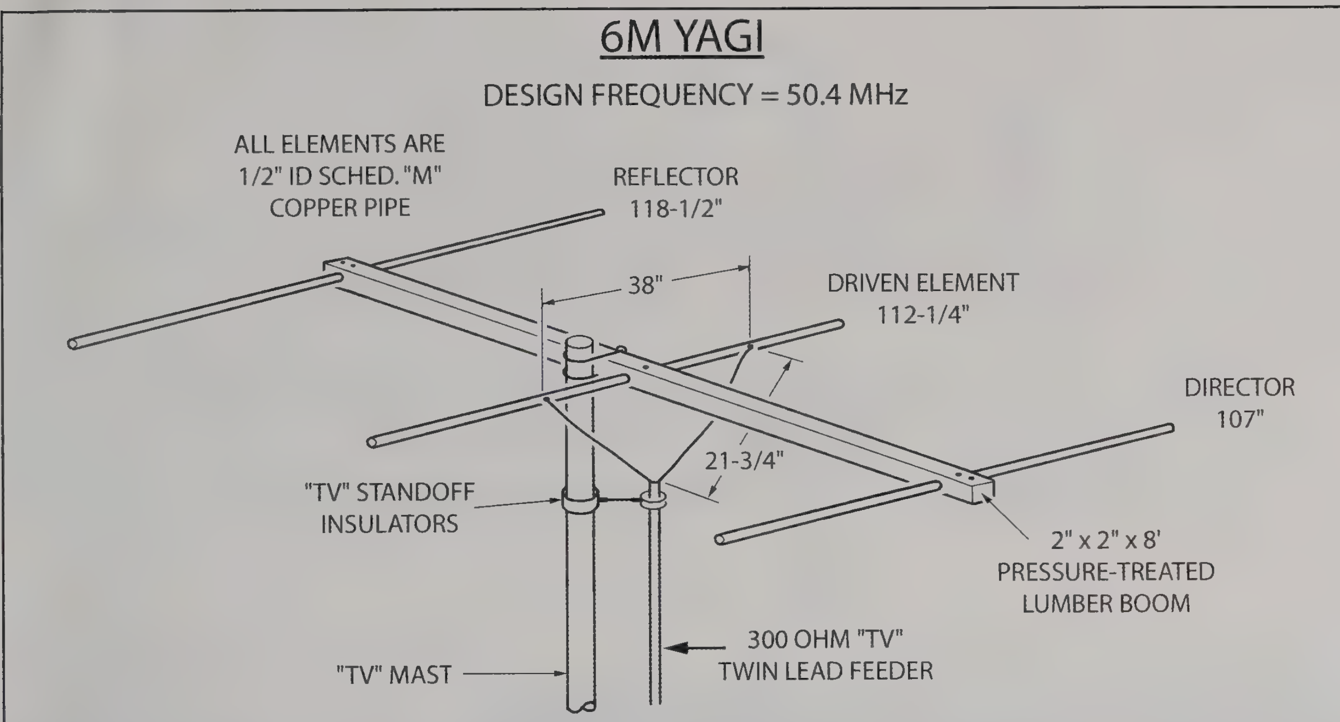


Figure 1. The completed three-element 6-meter beam. (Drawings courtesy Randy Kaeding, K8TMK, Heathkit Co., Benton Harbor, MI)

of a roll cutter will reduce the diameter of the cut end, causing difficulty if "tuning stubs" are inserted in the element ends, as described later.) Remove any burrs from inside the cut ends by reaming with a knife. Chamfer the outside ends of the elements with a file so they can easily be pushed through holes in the wood boom.

To make a light, low-loss boom, select an 8-foot pressure-treated 2 × 4 that is free of large knots along one edge. Rip a full 2-inch wide piece from the "good" edge. Bore a 5/8-inch hole at the center of the boom and 1 1/2 inches in from each end, to accept the pipe elements.

To secure a snug fit for the pipe, file a few thousandths of an inch from each side of a 5/8-inch paddle bit. Use the bit in a drill press, or have someone guide you while boring the holes, to be sure that the three holes are at right angles to the boom so that the elements will be in the same plane.

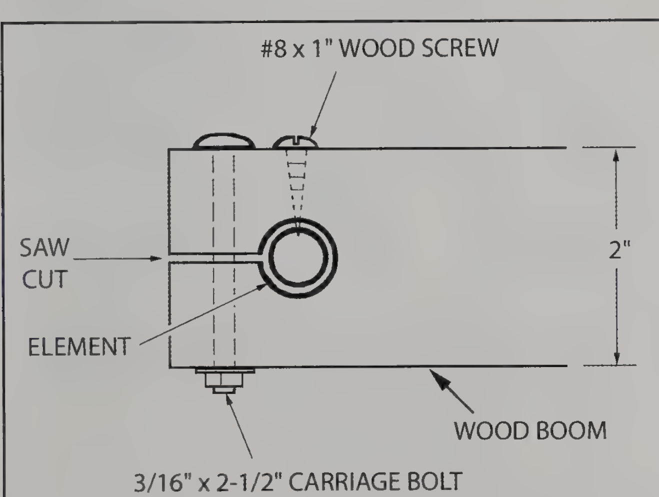


Figure 2. Attaching the elements to the boom.

Slit the ends of the boom back to the 5/8-inch holes, and then drill holes vertically through the slits to accept 3/16 × 2 1/2-inch bolts to clamp the elements in place(figure 2). Center the elements in the boom and tighten the clamp bolts. One-inch #6 wood screws can be driven through the boom into the elements to further hold them in place.

Select a mast stub about 2 1/2 feet long that will fit into the rotor (generally 1 1/2 inch OD). The mast stub should be long enough so that the feedline can be attached to it with a pair of TV standoff insulators, just below the delta fan-out.

Mount the mast to the boom between the reflector and driven element, about 4 inches from the driven element (figure 3). This will be the approximate horizontal balance point of the beam, since the reflector is about 10% heavier than the director, and will allow the delta match feedline to be fastened to the mast stub with stand-off insulators so that it is at a right angle to the driven element.

With two 1 1/2-inch U-bolts with clamps from two 2 1/2-inch U-bolts, clamp the mast to the wooden boom. This method of mounting requires no additional holes in the boom, which would weaken it.

Tuning the Beam and Delta-Match

An SWR analyzer (or transmitter and SWR indicator) plus a balanced antenna coupler and 300-ohm carbon (non-inductive) resistor are needed for the tune-up procedure. Set the analyzer frequency to 50.4 MHz and connect it to the coupler's input with a short length of coax. With a 300-ohm resistor connected to the coupler antenna terminals, adjust the coupler for an

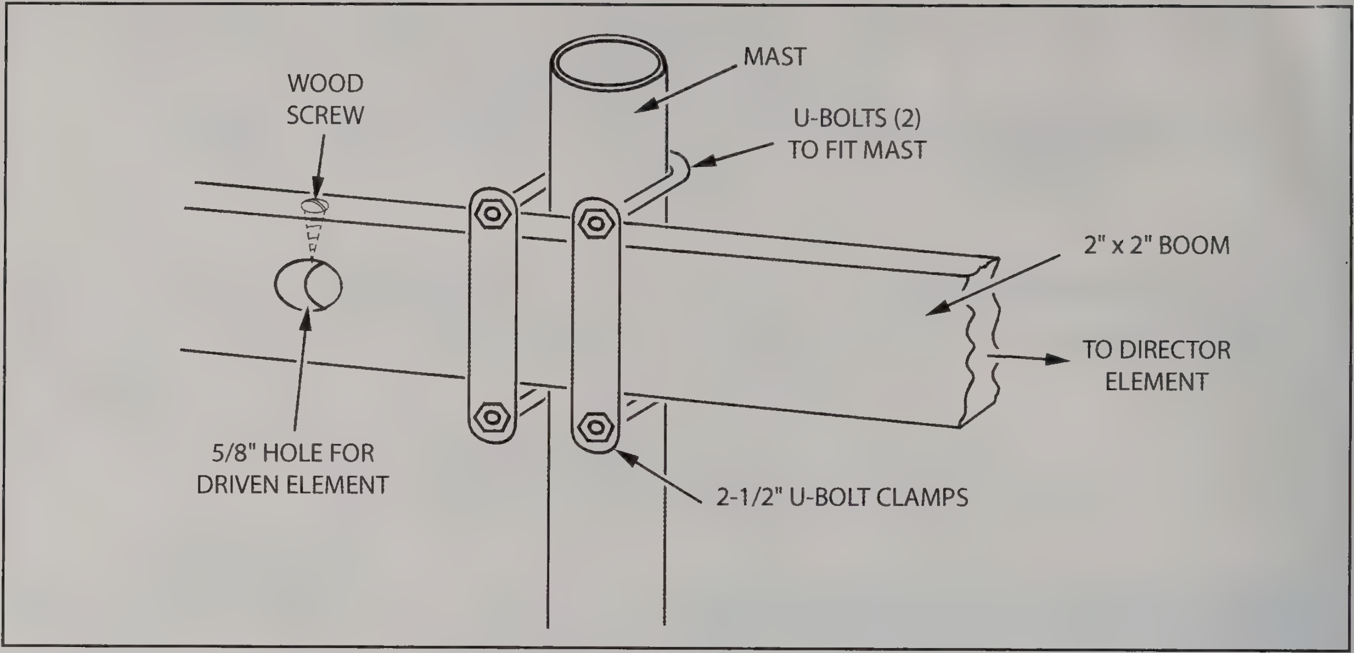


Figure 3. Mounting the mast to the boom.

SWR indication of 1:1. Thus, the coupler is set to "expect" a 300-ohm resistive load at the design frequency.

Support the beam on a wooden patio or on a pair of wooden chairs or saw horses with the beam aimed straight up (reflector element nearest the ground and parallel to it). Keep the beam at least one wavelength (20 feet) from metal such as aluminum siding or lawn furniture.

Make the delta match by separating the conductors of the 300-ohm feedline for a distance of 22 inches and skin the insulation from the ends. Attach the ends of the delta to the driven element at points 19 inches either side of its center by use of "Ideal" #5203 "Micro-Gear" automotive hose clamps. These clamps are tightened with a 1/4-inch nut-driver and facilitate the adjustment process (figure 4).

Remove the resistor from the coupler's antenna terminals and connect the 300-ohm feedline. Do not change the coupler adjustments during the tune-up procedure. Check the SWR indication at the design frequency. If it is not 1:1 at 50.4 MHz, adjust the locations of the delta match on the driven element by 1/2 inch or so, keeping them equidistant from the center of the element to provide a low SWR indication. Then adjust the analyzer frequency for lowest SWR, which is the resonant frequency of the system.

If the frequency is too low, cut 1/4 inch from each end of each element and again check the SWR and resonant frequency, and adjust the delta connecting points for lowest SWR. The driven-element length and the delta-match connecting points on it are the most critical adjustments, while the 21^{3}/4-inch fan-out length of the delta match appears to be the least critical.

The driven-element resonant frequency is somewhat dependent on the delta-match connecting points on it. This "de-tuning" effect of the delta is caused by a phase shift of current in the resonant driven element by the resistive load of the delta, the same as a resistor connected across a portion of the inductor in a resonant L-C circuit will change its resonant frequency.

The beam's resonant frequency is dependent on the lengths of the reflector and director as well as on the driven element. Thus, when "pruning" the driven element for resonance, also prune the parasitic elements to maintain the reflector approximately 5% longer than the driven element, and the director 5% shorter.

If the beam's resonant frequency is too high, tuning stubs can be used to extend the elements and thus lower the resonant frequency. From the 2-foot or so sections of 1/2-inch copper pipe that were cut off to make the elements, cut six pieces of pipe 4 inches long. Cut a 1/4-inch wide slot lengthwise in each piece using a hacksaw. Squeeze the pieces in a vise on alternate sides to reduce the outside diameter to about 1/2 inch, and chamfer one end with a file and clean with steel wool so that they can be pushed with a snug fit into the ends of the elements.

(Continued on page 74)

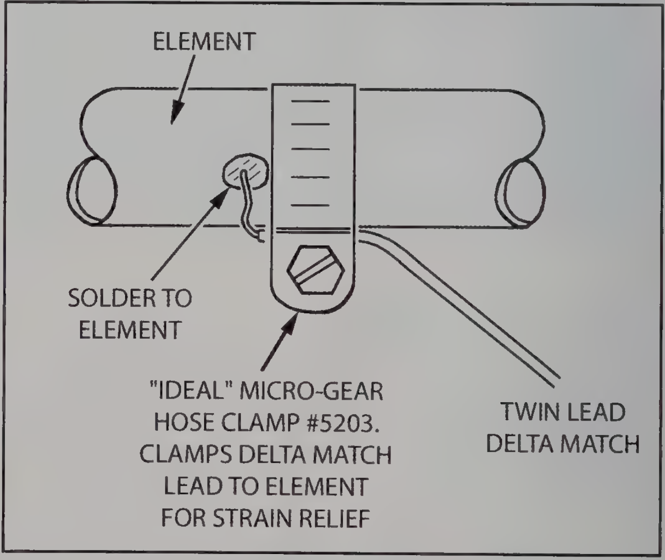


Figure 4. The clamp around the element holding the twin lead in place.

CQ VHF Reviews:

The ICOM IC-7000 HF/VHF/UHF Transceiver

For most of last year ICOM teased us with pictures of its new IC-7000. When it finally arrived in ham radio stores near us, N5AC was among the first in line to purchase one. Here he gives us a tour of the new radio.

By Steve Hicks,* N5AC

The ICOM IC-7000 was released this past December and I picked up mine on Wednesday, December 7th. The IC-7000 is the first truly mobile amateur HF transceiver that has a TFT color LCD display. The 2.5-inch diagonal display shows standard radio functions and is quite similar to that of the IC-756PRO line. The frequency display is large and easy to read from different angles and can be shown in three different colors and a couple of different type styles. It is very well thought out.

The TV

One unique capability of the radio is that as designed in Japan, the radio can display NTSC VHF video channels 2 though 13. As shipped in the U.S., however, this capability is disabled due to potential liability issues. Fortunately, the radio is easily modified to enable the TV feature and simply requires the removal of a diode that is read by the radio's microprocessor on power-up. (See the accompanying sidebar for the modification.)

The IC-7000 also has a beautiful operating display that shows frequency, memory information, power out, SWR, compression, and even radio temperature all at the same time. This has become my favorite radio display (see photo). For times when other information is displayed on the lower half of the screen, you can select which of the meters is displayed just below the frequency readout —power out, SWR, compression, or ALC.

The IC-7000 has a beautiful operating display that shows frequency, memory information, power out, SWR, compression, and even radio temperature all at the same time.

The TV display is nicely done and even has the capability of viewing an NTSC signal on any frequency from 49–218 MHz, in addition to standard U.S. TV channels. Although the TV side will not tune directly to the UHF channels for ATV (I confirmed this with ICOM), downconverters such as the TVC-4G from P.C. Electronics ($59 kit, $99 assembled) should work fine with the IC-7000. This has some nice implications for use in public service, ballooning, rocketry, etc.

The IC-7000 does not have dual-receive like so many of its big brothers, so when watching video, you are not able to transmit (the mic button is disabled) or monitor another channel. Still, the promise of being able to switch over and see a video feed from a descending balloon or for a net control in the local EOC to be able to pull up video at the disaster site is very real.

Much discussion about watching TV while driving down the highway has surfaced on the IC-7000 e-mail reflector. While it seems obvious that this is a "no-no," most who have the 7000 probably will enable the video, and many will run the IC-7000 as a mobile rig. If you're driving home at 6:05 PM and the FM radio station and your local repeater aren't interesting, it would be tempting to turn on the TV and just listen to the local news.

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Modifying the IC-7000 for TV Reception

The ICOM IC-7000 just released in December 2005 promised to have the capability to receive TV broadcasts off air and display these on the IC-7000's $2^1/2$-inch TFT display. The feature was disabled at the last minute due to liability concerns, which is understandable given the many disparate state laws on TV displays in vehicles. Re-enabling the TV functionality is simple and can be performed by anyone who feels comfortable with a soldering iron and a pair of tweezers. In addition, the out-of-band transmit modification can also be done at the same time. Keep in mind, though, that making modifications to your new radio may void the warranty. Therefore, proceed accordingly.

Because you will be inside a microprocessor-controlled unit and you will be removing the processor unit itself, it is best to have all tools ready and in one place before beginning. Static discharge can harm or destroy parts of the radio and static buildup is always greater in the dry winter months. Be sure to touch the outer chassis of the radio and discharge any static buildup if you do find yourself walking around the room during this procedure:

1. Remove the top cover of the radio using a Philips-head screwdriver by removing two black screws on each side of the radio holding the top (total of four) and four screws on the top of the radio not immediately adjacent to the speaker (see photo A).

2.The cover of the radio should lift up easily. The speaker cable snakes under the CPU/DSP unit (business-card-size metal enclosure) and can be moved out from under this module. It is not necessary to unplug the speaker. The cover can be just set to the side or if you are more comfortable you may unplug the speaker.

3. Remove two silver screws holding the CPU/DSP module in place (see photo B).

4. Pull up on the CPU/DSP module and remove it from the radio. The unit can be set to the side.

5. Directly under the DSP unit are a number of integrated circuits. Between the two white connectors that the CPU/DSP unit plugs into are four identical integrated circuits, three in a line and one next to the left-most one in the line. These are CMOS 4094 shift registers that are used by the processor to read the diodes on the board that control radio options. All four chips on my radio have the Texas Instruments logo and the part number "HJ4094."

6. Toward the front of the radio are rows of surface-mount (SMT) diodes. The diodes have silver paint on top and the letter "A" clearly marked. Using the supplied photograph, you may remove one

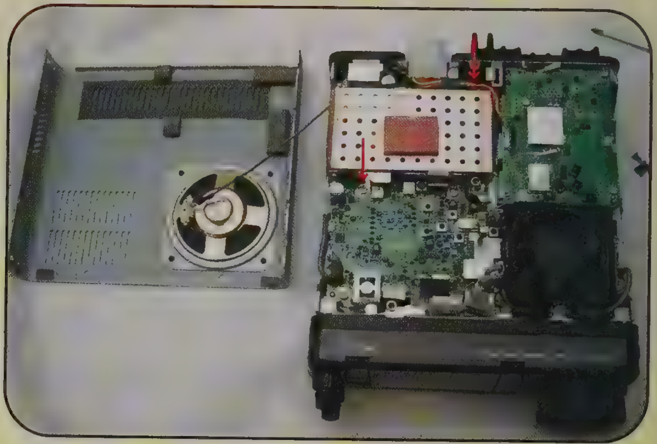

Photo B. Arrows point to the two screws holding the CPU/DSP module in place. Step 3 requires their removal. Step 4 requires the removal of the module.

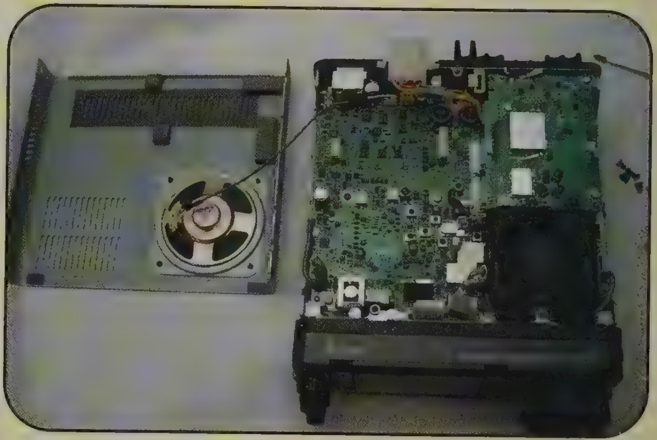

Photo C1. With the CPU/DSP module removed, the four 4094 shift registers are exposed. They can be identified by the Texas Instruments logo and part No. "HJ4094."

Photo A. The ICOM IC-7000 HF/VHF/UHF transceiver. (All photos courtesy of N5AC)

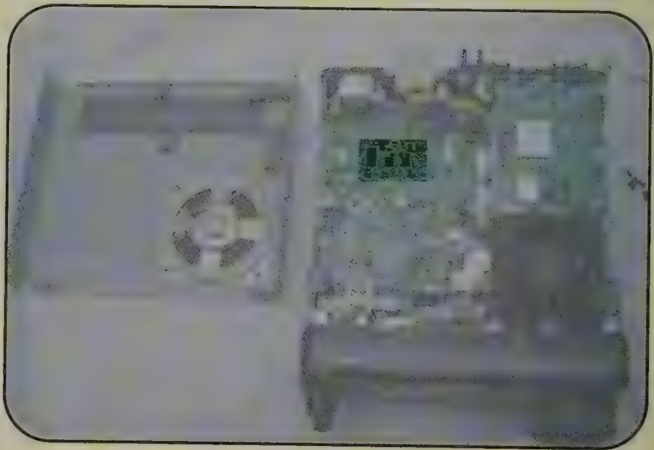

Photo C2. This photo highlights the four 4094 shift registers mentioned in step 5.

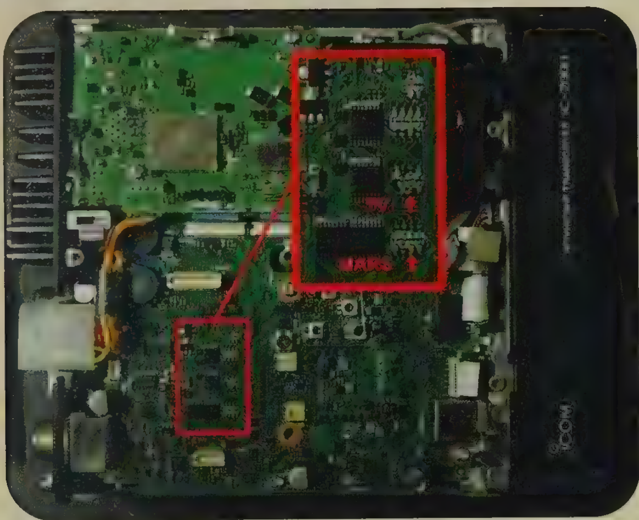

Photo D. Arrows point to the SMT diodes targeted for removal for the modifications. See steps 6 and 7 for instructions on how to remove them. Note that this photo is oriented 90 degrees counterclockwise from photos B, C1, and C2.

diode for TV reception enable and another diode for MARS out-of-band transmit enable. The diodes may be removed in any number of ways. For most with limited equipment, a good pencil iron and a pair of tweezers can be used. I generally alternate heating up either side of the diode (there are two pads that barely stick out to each side of the diode on the short sides) with the iron and applying gentle pressure to the diode until it moves. Once it moves, it will have moved off both solder pads because it is so small. I then wrestle it into place with just one pad touching and reheat the diode to get it to adhere to the board. This is so that I can go back and add the diode back later if need be. With just one lead soldered, the diode will not operate in the circuit and will be in the radio if you need it later. You may also remove it completely if you like.

7. To enable TV, remove diode number two on the left of the set of diodes in front of the middle 4094 (see photo C).

8. For MARS operation, remove diode number two on the left of the set of diodes in front of the left two 4094s (see photo D).

9. When you are done with the diodes, just reassemble the radio in reverse order. After putting the CPU/DSP unit back into the radio, be sure to slide the speaker cable gently under the upper left and lower left corners of the CPU/DSP module. If you do not do this, you will have trouble putting the top back on the radio.

To use the TV receive mode, press and hold the upper-left knob marked AF(SET) on the radio for one second. The normal radio screen will be replaced with a TV receiver screen. The receiver will tune US TV broadcast channels 2–13 by using either the band-up and band-down buttons or the [M-ch] inner knob on the lower left of the radio. TV channel 2 uses the HF antenna port on the back of the radio, while TV channels 3–13 use the VHF port on the radio. Specific channels can be tuned to a different frequency in the 49–218 MHz range and can be skipped from the channel-up and channel-down function by pressing in the AF (SET) button momentarily and following the prompts.

You can also put an ATV downconverter between the VHF antenna port and your antenna to receive ATV. Such a downconverter is the TVC-4G from P.C. Electronics. The website is: <http://www.hamtv.com>. Unlike your TV set, however, RF can come out of your VHF port, so you will want to be sure not to transmit through your ATV downconverter after you are through watching ATV.

While listening, would you avoid looking at the screen if a video of the overturned tanker on the highway were shown? It's easy for all of us to say that we wouldn't watch TV while driving down the road; it's probably a little more difficult to avoid doing just that if some compelling video were to be shown. Something to think about.

The Scope

While the IC-7000 also has a spectrum scope like the IC-756PRO radios, it is not as functional as the bigger rigs (see photo). The most obvious difference is in the way the IC-7000 sweeps the band scope. While it is not a "live" scope as in the IC-756PROIII or the IC-7800, this is definitely an improvement over the IC-706MKIIG.

As with the IC-706MKIIG, the 7000 does not have a separate receiver dedicated to the band scope; the receiver is taken "off line," muted, and used to create the band scope. In the slow-speed mode, a tick can be heard about every fifth of a second while the receiver is used to get data for the scope. This does not drastically affect intelligibility of the incoming signal, but the scope takes about five seconds per pass to display. At this speed, you could easily find signals that are either always present or are present much of the time.

To find more intermittent signals, the scope can be put in the fast mode. In this mode, the ticks are about every tenth of a second and render virtually unintelligible the incoming audio on the current channel the radio is monitoring (you can also mute the audio entirely). In trade, you get a much more real-time view of the spectrum. The radio takes under a half-second to display the entire range, which can be varied from 10 kHz to 250 kHz. This is clearly a real first for a mobile radio.

Weak-Signal Work

For weak-signal contest work, the question of when and how we might use this scope arises. I wondered how strong of a signal is required in order for it to appear in the spectrum scope. I hooked up my HP 8640B signal generator and put it on 144.100 MHz. I was able to hear a signal at –145 dBm on the IC-7000. I put the band scope on in both fast and slow and found that it took a signal of about –95 dBm before it showed up on the band scope. I have yet to test if this is an absolute or relative value. In other words, if I use a preamplifier that provides significant gain, would this improve the abilities of the spectrum scope? For example, if I have a 25-dB preamp, will I only need a –120-dBm signal before the signal appears in the band scope? This is simple to test, but I've just not had the opportunity.

The question here is if you are meeting someone on 2304 and they're not exactly on channel, would you be able to jump over to the band scope and quickly find them. The received signal would need to be well above the noise for you to spot it on the scope, so conditions and the received signal level will dictate whether you will be able to use the band scope for this purpose. You can also use the band scope as a mini spectrum analyzer for work under 470 MHz.

The DSP

ICOM has moved the DSP functionality from after the AGC to inside the AGC loop. For a mobile VHFer this has the poten-

(Continued on page 76)

Calculating Tropospheric-Scatter Propagation Losses

This article was originally presented as a paper at GippsTech 2005, the Annual Australian Conference designed to encourage participation in VHF, UHF, and Microwave amateur radio operations. The name *GippsTech* is a hybrid name for the technical conference being held at the Gippsland campus of Monash University. Gippsland is a region within the state of Victoria.

By Rex Moncur,* VK7MO

With the advent of Joe Taylor, K1JT's WSJT software program it is possible to work distances of 700 km and more on a regular basis on VHF and UHF using tropospheric scatter. Thus it is useful to have an understanding of tropospheric-scatter losses so we can see what is possible and understand the factors that affect these losses. A number of methods of calculating tropospheric-scatter losses from the amateur literature and Consultative Committee International Radio (CCIR) Report 238-5[1] have been applied, but they produce substantially different answers. The CCIR methods are not easy to apply and this can lead to errors. This paper aims to provide a better understanding of the limitations of the various methods and concludes that CCIR method 1 is to be preferred. Based on this method, look-up tables of propagation loss in temperate climates are developed to make the method user friendly.

Tropospheric Scatter

Tropospheric scatter arises from radio waves being scattered by small cells of different refractive index in the atmosphere. It allows signals to be detected at much greater range than line of sight or by diffraction around the Earth. Figure 1 shows the geometry of a tropospheric-scatter path.

Factors that affect the propagation loss are distance, frequency, and the scattering properties of the common scattering volume. The scattering properties vary with height and climate and the scattering angle. Both the scattering angle and the height of scattering vary as a function of distance due to Earth curvature and horizon obstructions. In addition, the effective Earth curvature is modified by the radio refractive index. All of these factors have an impact on the calculation of tropospheric-scatter losses. Simple methods of calculating tropospheric scatter take into account only distance and frequency, while others also include obstruction angles, climate, radio refractive index, and path reliability. There are also differences in the ways in which these factors are considered, with some being based on approximate empirical formulas and others on graphs derived from experimental results.

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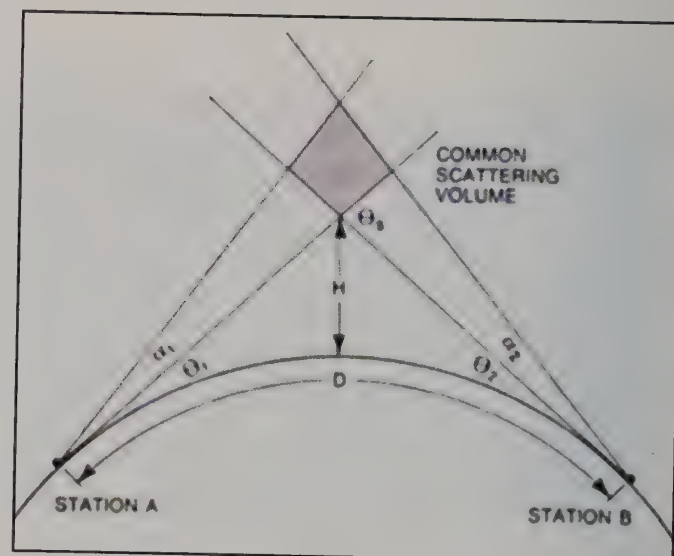

Figure 1. Geometry of a tropospheric scatter path where D (or d) is the distance between the stations, θ_S is the scattering angle, θ_1 and θ_2 are the horizon angles at each station, and $\alpha 1$ and $\alpha 2$ are the beamwidths of the antennas. (From ARRL UHF/Microwave Experimenter's Manual[2]*)*

Example Calculations

In Table 1 a range of methods available in the amateur and professional literature and CCIR report No238-51 are used to calculate the tropospheric-scatter losses for a 2-meter path of 500 km based two situations:

- A smooth Earth (no horizon obstruction) and
- 2.5 degrees obstruction at each end.

In order to give some equivalence to the various methods that include variables, the following are used or assumed:

- The surface radio refractive index is 320
- The region can be classified as continental temperate.
- Aperture to medium coupling losses are zero
- The required path reliability is 50%

Source	No obstruction (dB)	2.5 degrees obstruction at each station (dB)
The VHF/UHF DX Book, edited by Ian White, G3SEK #	–609	–559
ARRL UHF/Microwave Experimenters Manual #	205	256
CCIR Chinese Method	208	237
VHF/UHF Handbook, edited by Dick Biddulph, G8DPS #	208	*
CCIR Method 1	210	233
The VHF Handbook, by William Orr, W6SAI #	210	*
CCIR Method 2	212	238
ARRL *The Radio Amateur's VHF Manual,* by Ed Tilton, W1HDQ #	214	*
IT&T Handbook 4th Edition	222	*

*These methods do not allow for obstruction losses.
Methods do not specify path reliability.

Table 1. Propagation loss for various methods under the conditions listed above.

The method used by the *VHF/UHF DX Book* (White)[3] implies a gain rather than a loss and is clearly wrong and should be discarded. The method used in the 4th Edition of the *IT&T Handbook*[4], was replaced in recent editions by CCIR method 1, so it can be assumed the earlier method was considered less accurate and should also be discarded. The remaining methods give answers within a 7-dB range for a smooth Earth, but with obstructions of 2.5 degrees at each end the range is over 20 dB.

The simplest method is that used in the *VHF/UHF Handbook* (Biddulph)[5], which provides two tables—one for free-space losses and a second for the additional tropospheric-scatter losses. It takes into account both frequency and distance. It makes no reference to path reliability and it applies to a smooth Earth only. For many amateur situations there will be a few degrees of obstruction at each station and the smooth Earth assumption will lead to significant errors. *The VHF Handbook* (Orr)[6] suffers the same limitations.

ARRL's *The Radio Amateur's VHF Manual* (Tilton)[7] goes a little further in that it provides graphs for loss with distance and frequency for path reliabilities of 50% and 90%. Unfortunately, the graphs are the wrong way around, and it suffers the limitation of the prevous methods of applying only to a smooth Earth.

The ARRL's *UHF/Microwave Experimenters Manual*[2] method has a formula that takes into account frequency, distance, and obstruction loss. Obstruction loss derives from scattering angle and is 10 dB per degree of obstruction. Path reliability is not specified.

The three CCIR1 methods all take into account the important variables. CCIR method 1 takes into account eight types of climate, and method 2 two types (temperate and tropical). The Chinese method is

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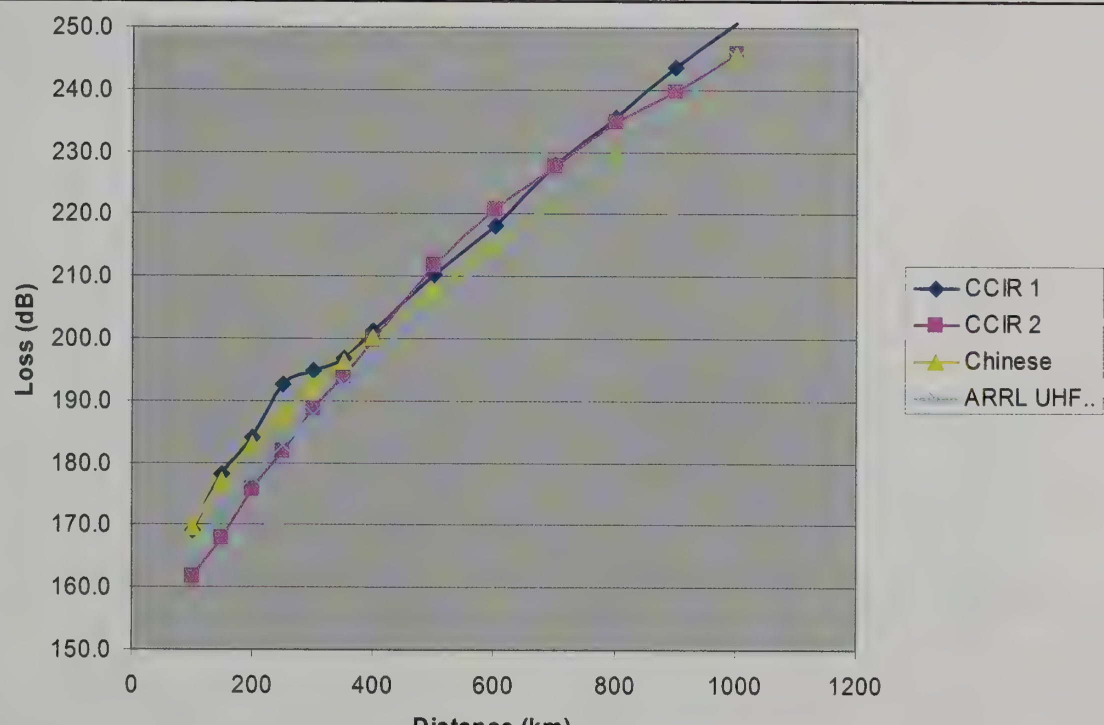

Figure 2. Variation of propagation losses with distance for four methods.

Predicting Propagation on 6 and 2 Meters, with Extensions to 70 cm

What causes sporadic-*E*? Can it be predicted? Answers to these questions have eluded us for decades—until now. In this article ZL3NE weighs into the debate by giving us his well-researched answers.

By Bob Gyde,* ZL3NE/1

It is general knowledge that the *F2*-layer absorbs most of the radiation that enters our planet's solar system and that it is also our shield from intense radiation. The intensity of the solar flux governs the amount of ionization that we can get into the *F2*-layer, and the *F2*-layer controls the ionization available for the *E*-layer. We also know that during the very low part of our solar cycle, *F2* propagation ceases on 10 and 15 meters because the amount of ionization arriving there is too low to support propagation on those bands.

The sporadic-*E* type of propagation, however, takes place regardless of the solar-flux readings. Therefore, the sun has nothing to do with sporadic-*E*—well, not by the previously accepted means. Ionization of the *E*-layer cannot be changed by radiation from outer space *when the observed solar flux level does not change,* and it would have to, to have any effect on the *E*-layer. Extreme flares such as X5 or above can temporarily change things, but only for a couple of days; after that we return to normal. The big thing to come to grips with is that *the ionization from the sun has nothing to do with sporadic-*E *type propagation.*

Determining What Produces Sporadic-*E* Propagation

With this statement as our basis, let us look at what we need to have to determine what produces sporadic-*E* propagation. First, we need an annual cycle to meet the traditional mid-summer peaks of propagation which occur between the December 10 and January 20 in the Southern Hemisphere and June and July in the Northern Hemisphere. Next, we need a means of varying the propagation direction, such as in the Southern Hemisphere. Examples are:

A. Propagation only from southwest to south on a yearly basis here at 37 degrees south.

B. A means of producing propagation only to the west and south on a yearly basis.

C. A means of producing propagation in all directions also on a yearly basis. A study of my extensive log shows that the described conditions do occur as stated, on a yearly basis. A classic example was during Cycle 23 between summer 1998 and 2000. At that time we constantly had the same weather pattern, one which gave us no propagation to the north. Therefore, during Cycle 23 we seldom made the *F2* areas, which in our case are only to the north of us.

D. In addition, we need some means of propagation that is possible even in mid winter.

Now that list was a tall order, but it covered my basic requirements.

It was now a learning curve for me, as I was sure weather could produce most of these conditions. However, how to have propagation in only certain directions for a whole season was hard to understand. Then I contacted our weather-office record department, and I was introduced to Dr. Mullin, who provided me with 50 years of records stating which time of each year the weather pattern was El Niño, La-Niña, and the one I did not know—Normal, or neutral. It was only then that I found I could fulfill all the requirements set by me with *weather conditions.*

By the time I had Dr. Mullin's records, I was well into my study, recording every contact along with the relevant weather maps, temperatures, etc. For several years I included these data sheets with each of my reports sent out annually. I calculated the number of contacts recorded over some 50 years on a yearly basis by each of the three weather patterns. These did exactly as required. El-Niño provided propagation all around, and Normal only west and south. These two gave good results, while La-Niña gave only the path to the south, with about one quarter of the number of contacts I recorded by the other two modes.

I had established a pattern of weather maps which fit in very nicely, and I could watch the propagation moving around each day until it came to here. Every time the weather map repeated itself as in previously recorded propagation, the same propagation re-occurred. In my last year I spent time each day recording the weather patterns that never produced propagation. There are many days of the year with no propagation, and in every case the same weather patterns were observed to be current.

Looking at winter propagation, we have temperatures much lower than in summer. However, even with cooler temperatures, the same weather maps work just as in summer. However, in the case

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of anticyclones, the air pressure needs to be much higher (typically 1036+mb), while with frontal activity it has to be a lot more intense, but propagation can and does take place.

At the end of about five years of study what had we learned? Had we found the missing links? I think so, as I could now predict to where propagation would take place and when. The accuracy of prediction was approaching 95–100% for the next day, equal to predicting the weather! As an aside, a lot of other things were discovered, but I will deal with them latter.

All propagation on 6 and 2 meters, and 70 cm, could now be predicted before it happened. Apart from AU (aurora) and *F2,* all other propagation is by tropo, or weather induced! To prove this you would need a reliable list of all contacts on the band you are studying, with the matching weather maps at the time the contacts took place. Nothing else is required, but it must be accurate. It will show that when propagation repetition occurs, the weather patterns re-occur.

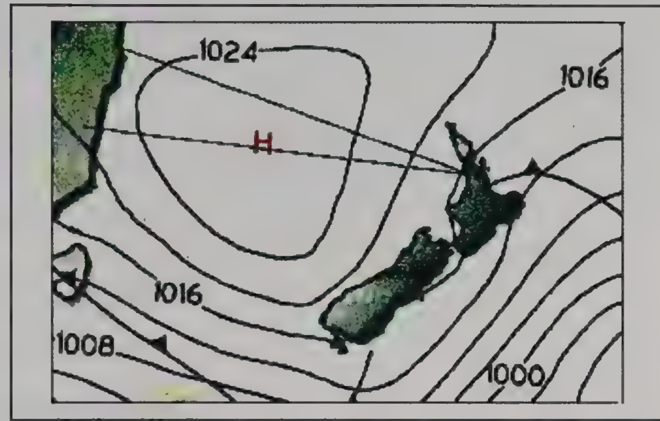

Figure 1. This is a typical anticyclone with 6-meter propagation shown.

Obtaining Provable Data

I found the only way to obtain provable data was by doing the required studies myself. There was some weather-related data (some 50 years of it), which our national weather bureau, NIWA, very kindly supplied. Otherwise the evidence I required was not available.

With this in mind, I undertook a three-year study of all contacts between three areas in Australia—Brisbane, Sydney, and Melbourne—as they were our main contact areas, and from Auckland to Christchurch, as this is a very strong signal area on 6 meters. The fourth year was spent studying North America and Europe to confirm that what was happening in the Southern Hemisphere was also happening in the Northern Hemisphere (and yes, it is).

I used the OH2AQ logging page for Europe and the dxworld.com pages for North America. With these I could compare the propagation taking place and the current weather from European and North American weather maps. While this was happening, I had access to several ionsonde reporting stations to study the *E*-layer ionization level under all conditions. To this day I do not know of anyone who has completed such a complicated study.

(I have been licensed since 1948 and came on to the VHF scene in the early 1950s, spending most of my time on 6 meters. By the mid 1970s I was quite sure weather was the main factor affecting propagation, and for the last 25 years I have been putting forward my beliefs on propagation. During that time I have written many papers on the subject, and even today my extensive study has found nothing different from what I had published!)

For my study, I recorded every contact that took place and the weather maps showing the weather pattern at the time the contacts took place. I recorded the stations heard or contacted on all three frequencies (6 meters, 2 meters, and 70 cm). As New Zealand is an ideal country to do this, with a very limited number of stations and directions in which to beam, I was not confused by secondary weather patterns. Here I was in a position where I could monitor the bands all day, every day, and until around 10 PM. My main monitoring antenna had unre-

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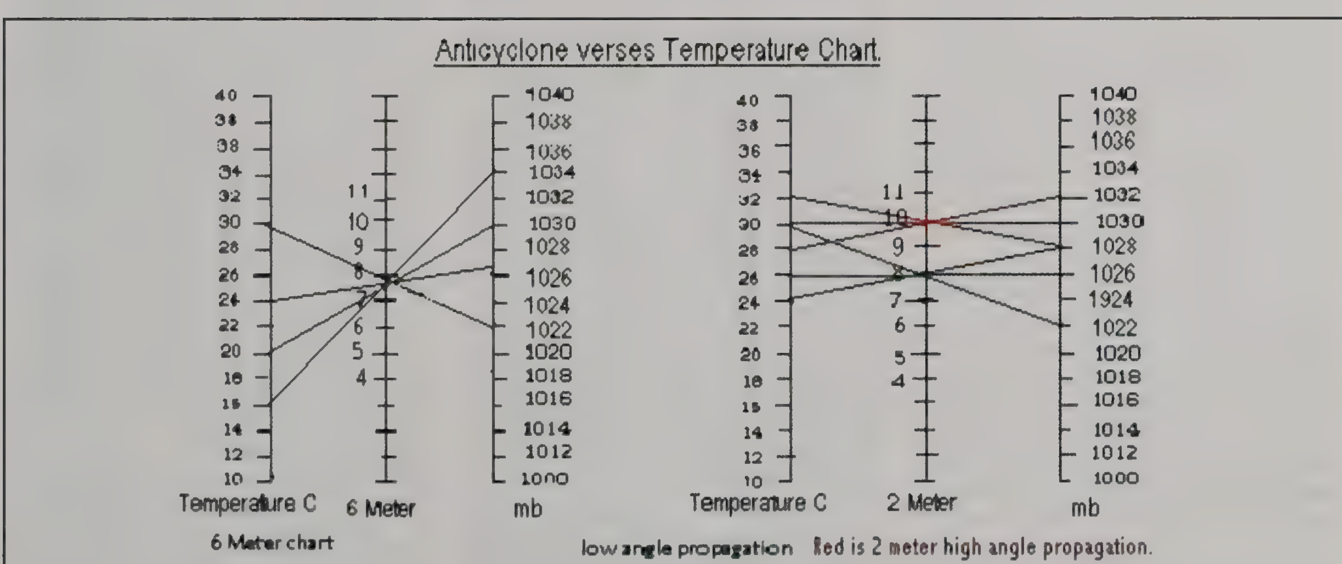

Figure 2. A chart showing the relationship between the air pressure and the air temperature.

Beacon Monitoring with DSP

Monitoring for propagation beacons is far more effective with DSP, rather than just hoping for a strong signal burst to trip your squelch. . . .

By Gordon West,* WB6NOA

When the DX and distant U.S. beacons begin to poke through the squelch circuit on 6 meters, you know the band is open somewhere in time to QSY up to 50.110 and 50.125 MHz to see who is on. Hundreds of 6-meter propagation beacons may be your first alert that the Magic Band is beginning to open!

On 2 meters and 125, 70, and 23 cm, propagation beacons help us keep track of tropospheric ducting opportunities. These VHF/UHF beacons begin to build slowly during a tropospheric duct and provide good clues as to the thickness of the duct, depending on which VHF and UHF bands are best bringing in the distant CW signals.

Propagation alerts over the internet are probably one of the best ways to hear when the bands are open, but for some of us, monitoring for propagation beacons is a passive way to hear the bands slowly or quickly open as the signal punches through squelch. Unfortunately, many new multiband VHF/UHF ham transceivers employ a squelch circuit that is gated either on or off by a transistor. Most of these "hard squelch" circuits also have slight histeresis, which means that any signal that triggers the squelch circuit open must be well above the background noise level. This unfortunate problem has caused many hams to miss a band opening and sometimes entire conversations just below the squelch-trip threshold point.

"I was listening for the Hawaii beacon on 144.170 MHz last Sunday, and I was careful to set the squelch just at the point where the background noise was squelched out. The radio was silent all day until a very noisy Ford drove by, briefly opening up the squelch circuit," comments Bill Alber, WA6CAX. Much to his surprise, there was an ongoing conversation between Bay area distant hams and Paul, KH6HME, in Hawaii. Without squelch, he could hear the signals weak but readable, but with any squelch setting the weak signal was completely taken out.

Shown here left to right are the GAP in-line DSP system, the SGC noise-subtraction DSP speaker (on top of the Kenwood TS-790), and the Heil Sound speech-amplified DSP speaker. All three systems worked well for monitoring beacons.

Older VHF/UHF multimode rigs—such as the Kenwood TR-751, Yaesu FT-726, and the very old KLM Multi 2000—incorporate a squelch system called the "Fujiama," a soft squelch system. The beauty of this squelch is that it allows you to monitor for weak beacons with your squelch setting right at the noise threshold and an occasional burst of white noise coming through to confirm the squelch sweet spot. Also, this type of squelch circuit has a slow decay, so any small signal opening up the squelch will keep the squelch open for a couple of seconds before the squelch slowly goes back into quiet monitoring. This has made Yaesu 726R and Kenwood TR-751 owners quite happy with their equipment, thanks to "soft squelch" capabilities.

However, there is a better way to monitor for CW beacons—using DSP (digital signal processing) with either a built-in DSP circuit on expensive rigs, or the relatively inexpensive DSP external audio systems from Heil Sound, SGC, and several great DSP add-on devices from Gap Electronics. Each requires 12 volts to power the external DSP module, which is built inside the speaker enclosure. Some of the DSP speaker systems offer up to five individual settings of DSP levels, but just two settings may be perfectly adequate. Plug the DSP speaker system into the external speaker output of your radio, and with 12 volts turned on, the add-on circuit usually comes up in the bypass mode.

Tune to the beacon frequency, adjust the volume to a pleasant level, and click on DSP. For the first couple of seconds nothing seems to happen. This is normal! Then the background white noise begins to slowly disappear. The first-level set-

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ting usually cancels about 75 percent of natural background noise. If you want up to 95 percent background noise canceling, go to the next or succeeding DSP levels. Remember, your squelch circuit is turned off all the way, and the DSP network is providing noise canceling.

As soon as that DSP network senses an intermittent incoming tone, such as CW, it instantly will pass that audio through to the speaker system. While the CW signal may sound as if it is wavering a bit, who cares? This is your alert that a CW beacon is beginning to poke through. When it comes time to change frequency and establish CW or voice communications with distant stations, you may wish to reduce the level setting of the DSP network, restoring signals to a more natural sound.

On UHF, you also may find that radar signals sometimes will creep through on every radar sweep. This sometimes is minimized by turning on the noise blanker or automatic noise limiting. Again, squelch off, DSP ON, and NL and NB turned on to help minimize radar.

You may listen all day without hearing a thing, but as soon as the beacon begins to show up on frequency, the DSP instantly will pass the signal through. Again, your radio's squelch is turned absolutely off, so the circuit is listening to nothing but white noise, searching for an intermittent incoming CW or voice signal.

Another bonus with DSP . . . more and more VHF/UHF operators using weak-signal modes at the bottom of the band are finding incessant "birdies" smack dab on the frequency that they hope is clear for monitoring the distant beacon. These birdies come from nearby computers, cordless phones, FAX machines, thermostats, and home entertainment systems all running with some sort of microprocessor clock. These interfering birdies may be a series of interfering tones that will drive you crazy!

Switch on the DSP system, and listen to what happens. Within about 5 seconds the modern DSP circuit analyzes the constant whistles and faithfully cancels them out! As long as the signal is constant, the modern DSP circuit knows not to pass it through and reduce it to nearly zero on speaker output. But guess what? As soon as that CW signal begins to come out of the noise, just a few Hertz different from the annoying whistle, the DSP circuit instantly will pass it through to the receiver. In fact, turn off the DSP circuit, and all you hear are the annoying birdie whistles; yet turn your DSP speaker system back on, and after about five seconds the whistles disappear and the faint sounds of the CW signal you are listening for reappear. Magic!

"It is magic," comments Bob Heil, K9EID, who now manufactures a base-station amplified speaker system with enhanced DSP capabilities. "Weak-signal operators are tired of missing weak band openings due to a squelch set right on the threshold but unable to pass the weak signal they are listening for. With DSP, white noise is cancelled, whistles are eliminated, and the only thing that gets through is CW and voice—exactly what they are listening for!" adds Heil.

So, if you are into monitoring for weak CW beacons, or don't want to miss an extremely weak signal just below your squelch setting, get a DSP system, turn off your squelch, turn on the DSP network, and hear nothing but peace and quiet until this very magic circuit begins to detect meaningful ham radio signals. ■

Public Service Event Guidelines

What makes for a successful public service event? Good guidelines. Here KC5ZQM draws from his experience in order to instruct us on how to have everything go smoothly.

By Douglas D. Lee,* KC5ZQM

Amateur radio has a long-standing tradition of providing communications during emergencies and disasters. To stay prepared for these events, hams also provide communications for parades, bike and foot races, walkathons, etc.

Public service events and emergencies have similar characteristics that affect communications: the need to move information quickly, the need to move information from one point to many, the need for one station to control the flow of information.

I have "worked" or organized close to two dozen public service events. Also, I was an Emergency Management volunteer from 1997 through 2000, with experience in storm spotting and communications. My communications background goes back to my days as a "commo" man in an Army National Guard infantry unit in the last half of the 1970s. My motivation for writing this article comes from my dissatisfaction with the way I have seen some public service events conducted.

My aim in this article is not to present myself as a final authority on the subject, but to suggest some guidelines that others may find useful. These guidelines cover the following:

- group-level preparations,
- individual preparations,
- working the event, and
- after the event.

Group-Level Preparations

If you are the public service officer for an amateur radio club, I know how busy you can be. As I write this, I have been the Activities Chair for the Tulsa (Oklahoma) Repeater Organization for almost two years. My duties include public service, some public relations, liaison with the Tulsa Area Chapter of the American Red Cross and Skywarn, plus organizing Field Day operations. Sometimes keeping everything straight can be a challenge. You need to give yourself every advantage to make things go smoothly. This section is for you.

Early Contact

Contacting the organizers of an event early can be an important key to success. Why? Some events have a different director every year. Some events cover a large area and require large amounts of resources, so the organizers may have a series of meetings you need to attend. For example, the Tulsa Run is a 15K (9.3 mile) race. It happens on the last Saturday in October, but the planning meetings begin in early September.

When you contact the event organizers, always confirm your club's participation and make sure they understand your primary role is communications. Your contact person may be new to his or her job and have no idea of what ham radio is, or what you can do for the event.

You also will need to confirm the particulars of the event:

- What it is, if it is not obvious from the name.
- Where it starts and stops; where the event control will be; how big an area it covers, etc.
- When (date and time); schedule of particular events (some races 5K and up will also have a "Fun Run").
- Number of operators and where they will be needed.
- When operators need to be on station.
- To whom the operators need to report.

You may get some of this information from your first contact, but most will come from planning meetings and/or communicating with the organizers. Do not hesitate to ask questions. Information is the raw material of the process of organization. *You* are responsible for getting the information you need.

Recruiting

Early contact with the organizers gives you a cushion of time that eases the pressure and stress of getting ready for the event. An early start to recruiting does the same. Even the best plans are useless if no one carries them out.

I recommend you start recruiting around one month before the event. Most recruits will volunteer within the last week or two, and during that time you may get all that you need. However, the extra weeks beforehand give you a better chance to get enough people on board. For events needing more than a dozen people, you may need to start recruiting two months in advance. For example, the Tulsa Run requires more volunteers than any other event I have organized. That extra month of recruiting has meant the difference in getting the people needed.

Fortunately, today we have many ways to get out the message about public service events. Of course, local nets on VHF/UHF repeaters are good channels for recruiting. Many of the net regulars will be active club members and ready to help out. Don't forget about DVR announcements on the repeaters, too.

Club meetings are another good avenue for recruiting. I have seen some clubs pass around a sign-up sheet, and

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many times very few will put their names down. Some do not want others to see their names on the list; some cannot commit at that time. On the other hand, I have had people respond positively when I approach them directly and personally. Another tactic I have asked for a show of hands of who has worked the event before and then immediately asked who will work it this year. That helped get about half the people needed for the 2005 Tulsa State Fair Parade.

If the club puts out a newsletter or has a website, make sure to get a short notice to the editor and/or web master. This is a good way to reach members who may not come to a meeting or check into a net, but they have time to spare on a weekend, when most public service events happen.

If you have been the public service officer for a while, you may have the e-mail addresses of volunteers for previous events. A group message will reach a more receptive audience.

If you do not get sufficient results from these methods, you can always grab a club roster and a telephone. I recommend you take a copy of the regular roster and eliminate the names of members you know will not be able to help with the event. This will save you time and frustration later.

As you gather names and callsigns, do not forget e-mail addresses, phone numbers (home, cell, and work), and T-shirt sizes (many events sponsors will give shirts to volunteers). Compile this information into a database; it may come in handy later.

For some events you may be able to accommodate volunteers with special needs, such as a need to leave early or to operate from a special location. Be sure to ask about these conditions.

Predetermine Assignments

As a volunteer, I have shown up at a command post for a public service event, and then waited to receive an assignment. The club officers in charge of the event often waited for maps from the event organizers before making assignments.

I was never satisfied with this practice. The club leaders knew for several weeks or months beforehand that the event was coming up. They also knew how to contact the event sponsors. Why didn't they contact the event organizers, get maps, and have assignments ready before the event? This practice of waiting for maps and assignments once unnecessarily cost me time and gas. I drove about 18 miles from my house in Kiefer, Oklahoma to West Tulsa. Then I drove about the same distance to my assignment between Sapulpa and Kellyville. My post was about 10 miles from my house.

I decided that when I was in charge of organizing communications for a public service event I would do as much planning as I could *before* the event.

My first event was the Maple Ridge Run on Memorial Day, 2004. This is a 5K race that takes place entirely within Tulsa's scenic and historic Maple Ridge neighborhood. This area has plenty of trees and attractive houses. It also has plenty of curvy streets that can easily confuse a visitor. The map the race director sent me only showed the course and not the streets. That was not acceptable as what I wanted to present to my volunteers.

Fortunately, I am a drafter. The race sponsors have a very good map of the neighborhood on their website (www.mapleridgeneighborhood.com). I clipboarded this image into my drafting program and traced over parts of it to create an image I could manipulate. I added arrows to illustrate the route and circled numbers to indicate checkpoint locations. For the 2005 event, I replaced the circled numbers with leader notes (arrows and text). I used a shareware program (PDF995, available from <www.software995.com>) to save it in .pdf format. This allowed me to e-mail the map to my volunteers and they could print out their own copies.

If you are not a drafter, you could find a map on the Internet, print it, make your own marks on it, and scan it back into electronic form. Some mapping sites and programs will allow you to add marks to a map, but I'm not sure you can get the results you want. I do encourage you to experiment with this, especially if you are not satisfied with the map supplied by the event organizers.

Most of the leader notes gave tactical callsigns for the assignments. Tactical calls speed up contacts by the Net Control, because the NCO does not have to remember or look up who is assigned to a specific position. Tactical callsigns are easier to remember because they tend to be descriptive, such as "Turn Two" or "Start Line."

When assigning volunteers, make sure the person matches the position. You want to put your more experienced and competent people in the most important spots. I'm not saying you can't trust newcomers. You just have to match experience and skill to need. Ed Compos, K5CRQ, has been licensed only a couple of years as I write this, and he is one of my best volunteers. He came into ham radio with plenty of experience as a law enforcement officer and firefighter.

Also, consider physical characteristics and needs. If you have someone following the Race Director, the "shadow" must be able to keep up. Someone lean and fit will work better than someone old and overweight.

When considering assignments, don't forget equipment needs. Some locations may require a mobile setup instead of an HT. Will you use VHF or UHF, repeater or simplex, or some combination of these?

Prepare Volunteers

You could send the map and assignments through a group e-mail, but I prefer individual massages. That allows me to give each volunteer the details he or she needs concerning his or her particular assignment. When a club meeting occurred in the week before an event, I handed out maps and assignments then.

You could give out assignments on local nets, but I do not recommend it. Nets should be used to pass on general information, the things all volunteers need to know.

Make sure to give your volunteers *all* the information they need. Here is a checklist:

- Location
- Tactical callsign
- Special duties
- Equipment and accessories (mobile or HT, headphones, flashlight, etc.)
- Clothing (comfortable shoes, rain gear, safety vests, etc.)
- Schedule (when to be on station, when net will start, etc.)
- To whom to report, if the location is staffed by event personnel.

Final Pre-event Contact

At least two days before the event make one more contact with the event organizers, preferably by phone. Assure them your people are prepared. If the event organizers are giving out T-shirts, give them a list of sizes and amount of each size needed. Ask about any last-minute changes.

For the 2005 Maple Ridge Run, Race Director Chip Ard made a last-minute change to the route for the Fun Run. The

1-mile Fun Run uses essentially the same route as the 5K, and it starts before the main event. Chip was concerned about the Fun Runners interfering with the 5K runners staging at the start line. He changed the Fun Run route to move its finish line away from the start line. He wanted a checkpoint half way down the extra leg. Fortunately, I had one more volunteer than I had predetermined assignments. I created a new assignment and tactical call for this volunteer.

Individual Preparations

To me, public service is the most significant, the most satisfying, and the most rewarding aspect of ham radio. When I was out there as a volunteer, I felt I was part of something bigger than myself and I was in a position to make a difference.

During one of my first public service events (PSEs), a bike ride then called the T-Town Trek, I was "sweeping" the route when I found a couple of riders too exhausted to continue. I called for the SAG (support and gear) wagon and stayed with the couple until it arrived. What a wonderful feeling it was to help those who may have been stranded out in the boonies for hours!

Preparation is just as important for the individual volunteer as it is for the public service officer. You can't do any good if you are in the right place and on time, but your batteries give out or your antenna breaks.

Get Informed

Just as the public service officer needs to be sure of the date, time, location, and other particulars of the event, you also need that information as a volunteer. You are responsible for getting the information you need. If you think you need to know something, *ask*, or look around on the Internet.

You have two good reasons for knowing as much as you can about the event: (1) The information gives you an idea of what to expect and prepare for, and (2) members of the public can see you on post and approach you to ask questions. If you can't come up with an answer, you will look bad, the club will look bad, and the event organizers will look bad.

If the club's public service officer notifies you of your assignment before the event, make sure you have complete information (see the bulleted list under the heading "Prepare Volunteers"). Once you have it, use it to prepare yourself.

If you are working a location or an event for the first time, try to familiarize yourself with the area beforehand and determine the best route to get there.

Get Equipped

Check to see if you have the needed equipment, accessories, clothing, etc. Also make sure you have back-ups for vital items: radios, antennas, batteries. Once while working the Tulsa Run, I was sitting in my fold-up camp chair when I noticed something long, skinny, and black on the sidewalk to my left. It was the radiating element from my HT antenna. The antenna was an aftermarket model, and I had the original with me.

The day before the event, charge up any batteries that need it. Fuel up your vehicle, too! You don't want to be late or get stranded.

While going through your preparations, don't forget your personal needs, such as sunblock, insect repellent, water, snacks, medicines, reading glasses, etc.

One thing that can simplify your preparations is a "go kit" or "jump bag." Such kits are designed for local emergency activations, so you may want to keep one in your car. A basic kit should have everything you need to operate for at least 24 hours. Refresh the perishable contents on occasion, such as when you have a public service event coming up. You can get a go-kit list from your local emergency management agency or ARES group. You can also find a list at <www.tulsahamradio.org>.

Working the Event

You wake up early on a Saturday morning, when you would normally sleep in (at least I would!). You packed some things in the car the night before, but after getting dressed, you grab the last few items you need as you head out the door. On your way to your assignment, you stop for a breakfast burrito and a cup of dark-roast coffee.

You think about what you are sacrificing for the sake of amateur radio and the public—sleeping in a comfortable bed with clean sheets; fresh eggs over easy with coffee, toast, jam, and juice for breakfast with the morning paper; the do-it-yourself TV shows you faithfully watch and then dream of replicating their projects with your own tools and your own hands, but you never actually do; the beam in the back yard that needs to go back on the tower.

You arrive at your destination. You have made all the recommended preparations plus some you thought of yourself. You figure all you have left to do is to just work the event. Well not quite. I still have some guidelines for you. however, before I continue, on behalf of amateur radio in general, I want to say thank you for volunteering!

For All Volunteers

Before the event: *Be on time!* The best way to be on time is to be prepared and to be *early*! Make sure you have all the info, gear, and supplies you need. Get plenty of sleep the night before. Get up early enough so you have time to get dressed, eat breakfast, finish packing, and drive to your assignment. Allow extra time for unexpected developments such as flat tires, detours, etc.

While gathering your gear and supplies, take everything you need, but not too much extra. Most public service events last only four to six hours, so you don't have to pack as if you are going on a safari. Take enough to get you through the event. If you can't go two hours without chocolate, take along a candy bar or two, but no more.

If your assigned position is manned by public service event personnel, report to the person in charge if you have not been given a specific name. Tell the person who you are, why you are there, and what you can do—for example, "Hi, my name is Doug. I am a radio operator assigned to provide communications for this water stop. If you need to contact the race director, the water truck, or the police, let me know and I will contact them for you as quick as I can." Explain clearly that your job is communications. If you help with other things, you will not have your attention on the radio, and you may miss an important call.

During the event: Follow the instructions of Net Control, *period!* As a communicator, your job is to make sure the right information gets to the right person or place at the right time by using the best means. The Net Control's job is to make sure all the other communicators do their jobs. public service events tend to be more orderly than the disasters they help us prepare for. In either case, nobody needs someone adding to the chaos.

Use your tactical callsign when making and answering calls. This will help Net Control manage things more smoothly; he or she does not have to look up or strain

to remember who is assigned where. Be sure to clear with your FCC-issued callsign according to Part 97 regulations.

Report emergencies *immediately*! If you do not understand why, you do not need to be involved in public service events or emergency communications.

Keep public service event personnel informed! That's why you are there in the first place. Do use some discretion. Do not repeat the name of an injured person, for example, even if someone asks.

Stay focused on the job at hand until the event is over. During long events, you may have to wait through extended periods of inactivity. Your attention could drift, or to break up the monotony, you start up some chitchat. The next thing you know, you've missed something you should have caught. Even if your assignment ends before the event is over, unless you have a good reason to leave, stick around. You may be needed to help another volunteer or to deal with some unforeseen development. This may sound like a yogism, but as long as you have a job to do, you have a job to do.

Even with all the serious aspects of public service events, don't forget to *have fun*!

For Net Controls

Open and close the public service event net with formal announcements. This lets stations not taking part in the net know that someone is using the frequency for a special purpose. Open the net about 15 minutes before the event. Take a roll call 10 minutes before the event to give your volunteers a chance to check their signals and equipment.

If an outside station wishes to make contact, they should ask permission from Net Control first. If the contact is allowed, the outside stations should immediately move to another frequency.

Emphasize tactical callsigns, but remember to have stations clear with FCC-issued callsigns. Some operators may be new to the idea of tactical calls, so they may need reminders.

To speed up communications during races, I usually allow two types of communications to go on without first going through Net Control. First, I let the start-line operator announce when the races have started. I also allow direct contacts with the race director's shadow.

Be sure to thank the volunteers on the air and in person. If you have to hand out T-shirts, you may have your volunteers gather at your location. That will give you a chance to thank them in person. You may also want to hold a debriefing then if you think one is needed.

After The Event

As I mentioned earlier, public service events help us prepare for emergencies and disasters. One big difference is that emergencies and disasters don't happen on a regular schedule. They tend to occur suddenly, at inconvenient times and places. Then how do public service events help us prepare for the "Real Big, Bad Nasties"? By allowing us a chance to practice using our skills at communicating, organizing, and planning. They get us thinking about things such as maps, assignments, controlled nets, batteries, flashlights, etc. After each public service event you have an opportunity to review what worked, what didn't work, and what you can do to be better prepared for next time.

If you are the public service officer in charge of the event, write an article for the club's newsletter and/or website. Don't just say, "The following members went to Suchandsuch Park to provide communications for..." Tell the story. Surely more happened than a bunch of people stood or sat around and talked on radios. Did the experience teach you a new lesson or reinforce an old one? Did you get hot, cold, sweaty, thirsty, tired, gritty, dusty, dirty, grimy, or any combination thereof? Inquiring minds want to know! You don't have to write a tabloid piece. Just tell a story in a conversational style. While writing, imagine you're telling the story to a friend over a cup of coffee.

Your article will do several things. It lets the club members know it is a viable, active group that provides a valuable service to the community. It gives recognition to the volunteers and confirms the value of their efforts. People also enjoy reading about themselves and their friends. Also, on the local nets once again say thanks to the volunteers and give a short report.

If you or someone else hasn't already done so, you may want to start a scrapbook. If such a scrapbook exists, add your article and photos.

Then get to work on your next public service event! ■

SMOGfest 2005

A Major Gathering of 6-Meter Operators

Even without W6JKV's annual barbeque last year, 6-meter aficionados met for a one-time fun-filled event in New England called SMOGfest.

By Ken Neubeck,* WB2AMU

A special T-shirt commemorating SMOGFEST was for sale and was a very popular item.

SMOGfest was held in a unique setting—an outdoor barbeque-style restaurant located in Exeter, Rhode Island. (All photos by the author)

More than any amateur radio band, 6 meters has its unique set of propagation modes. The band is loved by a hardcore group of aficionados. On September 24, 2005 an event was held in Rhode Island. Known as SMOGfest (the Six Meter Operators Group 'fest), many of these 6-meter aficionados attended. This was a once-in-a-lifetime gathering for many, and 6-meter operators were able to meet one another in person. Some of these ops had been worked via aurora, sporadic-*E*, and even *F2* on the 6-meter band!

The event was planned when well-known 6-meter DXer Jimmy Treybig, W6JKV, was not able to conduct his annual barbeque on his ranch in Texas in 2005. Acting quickly, several New England hams worked to put together an alternate event at an East Coast location. John (Mick) McManus, W1JJ, along with Dennis Motschenbacher, K7BV, Steve Gilbert, K1SG, Ivan Pagacik, K1MS, and John Allen, K1AE, found a great location with an outdoor-style restaurant known as Yawgoo Bakes and Barbeque in the rural town of Exeter in Rhode Island. Invitations were sent to over 150 six-meter operators.

It was a beautiful fall day for the New England area, with temperatures reaching almost 70 degrees F. Approximately 100 people attended this event—about 80 six-meter ops and 20 YLs. All operators had sent in their QSL cards with payment for SMOGfest, and from these cards some really great badges were made! People came via plane, ferry, and automobile. Most of the attendees were from the East Coast, with good representation from the 1, 2, 3, and 4 U.S. call areas and the VE2 and VE3 Canadian call areas. However, some came from farther away: Pat Rose, W5OZI, from Texas; Ned, AA7A, from Arizona; and Doug, VE5UF, and Andy, VA6SZ, from the western provinces of Canada. Tom Gallagher, N6RA, made the trip from California, and he brought logs and QSLs from his recent DX trip as FP/N6RA. Many others brought QSLs to confirm contacts made with the attendees.

From left to right: Mick, W1JJ, one of the event's organizer, speaking with former QST VHF columnist Emil, W3PP, and current QST VHF columnist Gene, W3ZZ.

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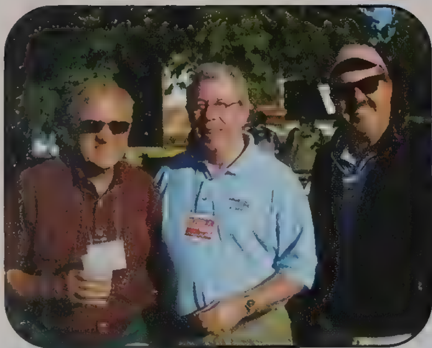
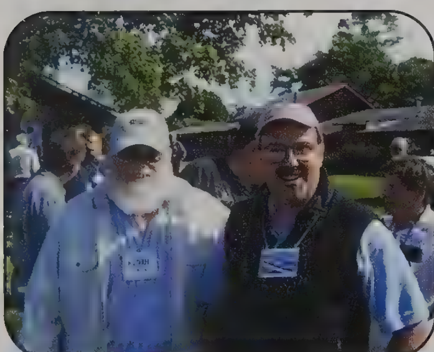
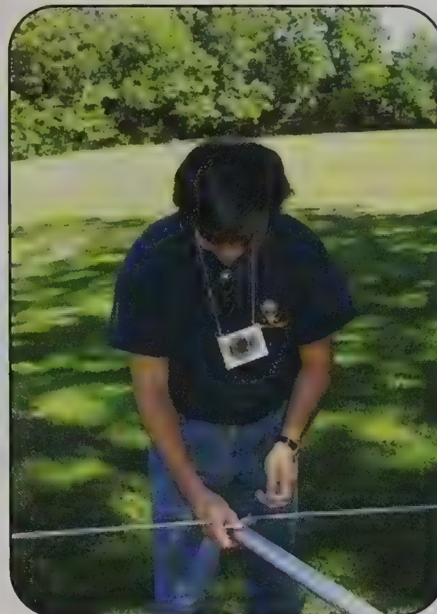


Another group shot with operators from left to right: Dave, K2SIX, Dennis, K7BV, and Clint, W1LP. Dennis had just arrived after participating in several weeks of health-and-welfare traffic assistance in the Gulf States affected by Hurricane Katrina.



Here are two well-known 6-meter operators: VHF contester Bob, K2DRH, on the left and well-known VHF maritime rover operator, Clint, W1LP, on the right. Bob has provided many contacts on 6 meters in contests, while Clint has activated many rare all-water grids on 6 meters over the years!

Several excellent presentations were given in one of the buildings on the site. Among others, these included subjects such as EME, the beacon project, and DXpeditions.



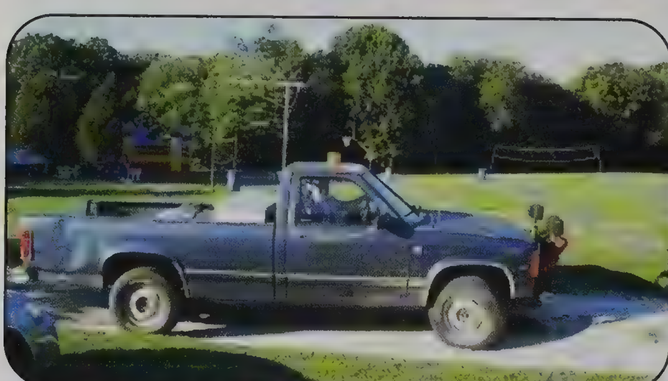
Working on the five-element Yagi is Kaz, K8KS, an eye laser surgeon from Michigan. He is one of the newer operators on 6 meters. Kaz started out on 6 about two years ago, but he has embraced the band in a big way and is very popular with many of the veteran operators on the band.

A thing of beauty—a five-element, 6-meter Yagi in an open field.

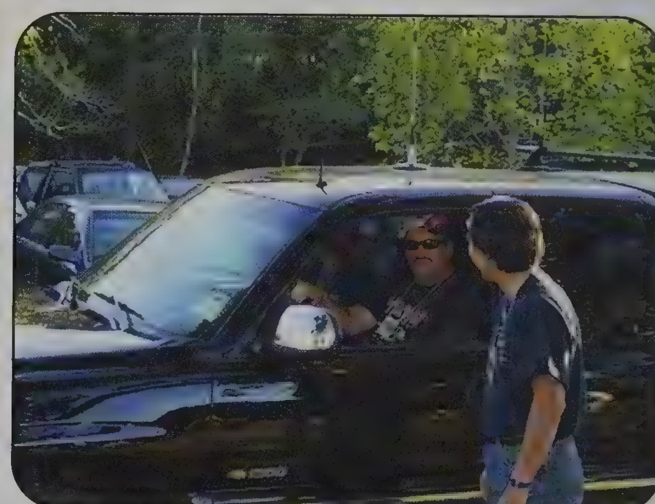
Here are some 6-meter operators from the aurora zone: Bob Mobile, K1SIX, from grid FN43 and Andy, VA6SZ, from DO33. Note the badges, which were specially made for the event.

The owners of two very well-known 6-meter beacons located on the East Coast: Mario Karsich, K2ZD (beacon located in FN20 on 50.068 MHz), and Steve Wilson, W1RA (beacon located in FN41 on 50.071 MHz).

The entire group of SMOGfest attendees sang happy birthday to Jimmy, W6JKV, via video to his home in Texas. This may have been one of the largest gatherings of 6-meter operators at any one time in the history of North America!



A number of operators brought their rover stations with them, including Frank, KB1LKB, with his 6-meter loop antenna situated on the back of his pickup truck.



Here is another mobile station with driver Frank, AA2DR, and passenger Joe, NA2P, talking to bystander Kaz, K8KS.

One of the buildings located on the SMOGfest site was used as a lecture hall for several talks and presentations on 6 meters. Besides N6RA's talk on his FP trip, there were presentations on other aspects of 6 meters, including EME (earth-moon-earth), DXing, and equipment. These were given by Ned, AA7A, Pat, W5OZI, Dave, N3DB, and Dennis, K7BV, among others. Several vendors, such as ICOM and Array Solutions, provided financial support and equipment for viewing. Mike Staal, K6MYC, of M^2 Antenna Systems, Inc., provided special "crying towels" for the 6-meter operators with the apropos saying "No 6 Meter Es . . . poor pitiful me."

During the day there was a five-element Yagi and ICOM IC-7800 (provided on loan) on the air. Unfortunately, there was no propagation brewing and few stations could be worked. Ah, the nuances of 6 meters!

The event began at around 11 AM and ended at about sundown for many of the operators. A number of smaller groups got together afterwards to continue various conversations about 6 meters. One day hardly seemed enough to everything of interest.

Many photos were taken at SMOGfest. This article presents some of the ones I took, but space is limited here. Check the special internet website put together by Al, K3TKJ, where many photos of the different hams at the event are provided by Mike, K8ROX, and Dave, N3DB. The site is: <http://www.smogfest.info>.

Many thanks go to the organizers of the event—W1JJ, K1MS, K1SG, K1AE, and K7BV—for making this a truly memorable experience for those who attended. It was especially gratifying for me to meet about two dozen operators whom I had worked on 6 meters; I had never before had the opportunity to meet them in person. I am sure that many other attendees have the same feeling I do and are also grateful to the organizers of the event for this unique opportunity. ■

QUARTERLY CALENDAR OF EVENTS

Current Contests

European Worldwide EME Contest 2005: Sponsored by DUBUS and REF, the EU WW EME contest is intended to encourage worldwide activity on moonbounce. Multipliers are DXCC countries plus all W/VK/VE states.

The contest dates and bands are as follows: First weekend—50, 144, 432, and 1296 MHz, 11–12 February, 0000 to 2400 UTC, digital only; second weekend—432 MHz and 5.7 GHz and up, CW/SSB, 11–12 March, 0000 to 2400 UTC; third weekend—144 MHz and 2.3 and 3.4 GHz, CW/SSB, 8–9 April, 0000 to 2400 UTC; and fourth weekend—1296 MHz CW/SSB, 6–7 May, 0000 to 2400 UTC.

Sections and awards include the following: QRP 144 MHz <100 kW EIRP, 432 MHz <400 kW EIRP, 1296 MHz <600kW EIRP, but no separate QRP/QRO categories. The QRO category on 144, 432, and 1296 MHz, stations with EIRP equal to or greater than stated above. The PRO category includes non-amateur equipment or antennas. PRO stations will have scores listed separately. CW/SSB: all QSOs in CW and/or SSB mode; no other modes may be used. DIG: all QSOs in digital mode (e.g., all the "JT" modes); no other modes may be used. ASS (Assisted): stations using liaison by any other means (e.g., DXcluster, logger, Internet, telephone) must indicate this and will be marked with an asterisk after their callsign in the results tables. ASS is not a separate section. Multi-operator and QRO stations will be highlighted in the general classifications. All QRP/QRO band winners and QRP/QRO multiband winners will receive a free year's subscription to *DUBUS* magazine. In each band/section, certificates will be sent to the top five entries and to the highest-scoring station in the southern hemisphere.

For a valid QSO, both stations must transmit and receive both callsigns+ TMO/RST/xxdB + R.

Logs: Logs must be separate for each band and should be in normal "logbook" format. Top line: Your callsign, Band. Each QSO: Date/time, Callsign, Report sent, Report received, Points, Multiplier. Bottom line: Total points, Total multipliers, Total claimed score.

QSO Points: 100 points for each random QSO completed. 10 (ten) points for each sked QSO completed on 144/432/1296MHz. 100 points for each random or sked QSO completed on 2.3 GHz or higher bands.

Multipliers: Each DXCC country (except W/VE/VK), or each individual STATE worked in W/VE/VK. States and provinces can be determined after the contest using newsletters, web, or callbooks.

Total Scores: Single band score = [Total of QSO points] × [Total of multipliers]. There will be one QRP winner and one QRO winner on each band. Multiband score = [(Total sum of points on 144–1296MHz) + (2 × total sum of points on 2.3GHz or above)] × [Total sum of multipliers on all bands]. There will be one QRP multiband winner and one QRO multiband winner. Multiband stations will also be listed as an entry on each separate band worked, and can also win single-band awards.

Contest Entries: Copy of the log for each band with details of points, multipliers, and total points. The following information *must* also be included for each band: (1) Output power, transmit cable loss, antenna type, and gain. (2) Categories: QRO/QRP – single/multi operator - ASSisted – CW/SSB –DIG. (3) Name(s) of all operators. (4) Locator/State. Other info is welcome—comments, conditions, locator, station details, photographs, etc.

Sending Your Entry: Contest entries *must* be sent no later than 28 days after the end of the last contest weekend (i.e., in the mail or e-mail by 7 June 2006). Entries for the *first* weekend (Digital) must be send no later than 28 days after 12 February (i.e., in the mail by 12 March 2006).

Mailing address: Patrick Magnin, F6HYE, Marcorens, F-74140 Ballaison, France.

You may also e-mail your contest entry in ASCII format to: <f6hye@ref-union.org>.

All e-mail entries will be acknowledged within one week. For further questions contact: <info@dubus.de>. Complete rules can be found at: <http://www.marsport.demon.co.uk/EMEcont2006.pdf>.

Spring Sprints: These short-duration (usually four hours) VHF+ contests are held on various dates (for each band) during the months of April and May. This year's dates and times were not available at press time. It is assumed based on last year's dates that they will be as follows *(however, please check with the sponsor)*: 144 MHz, April 3, 7–11 PM local time; 222 MHz, April 11, 7–11 PM local time; 432 MHz, April 19, 7–11 PM local time; Microwave, May 6, 6 AM to 1 PM local time; and 50 MHz, May 13–14, 2300 UTC Saturday until 0300 UTC Sunday. Logs and summary sheets should be e-mailed or snail mailed to the addresses below. Logs should be submitted within 30 days of the end of each contest. Contact information: Jeff Baker, WU4O, 2012 Hinds Creek Road, Heiskell, Tennessee 37754; e-mail: <springsprints@etdxa.org>. Sponsored by the East Tennessee Valley DX Association. The up-to-date information on these contests can be found at <http://www.etdxa.org>. At this URL, click on the VHF/UHF link to go to the contest info.

2 GHz and Up World Wide Club Contest: The following is unofficial and is developed from assumptions based on last year's contest *(check with the sponsor for confirmation)*. Sponsored by the San Bernardino Microwave Society, this contest should run from 6 AM on May 6 to 12 midnight on May 7 (36 hours). The object is for worldwide club groups of amateurs work as many amateur stations in as many different locations as possible in the world on bands from 2 GHz through Light. Rules are available at the following URL: <http://www.ham-radio.com/sbms>.

Quarterly Calendar

Feb. 5	First Quarter Moon. Moderate EME conditions
Feb. 12	Good EME conditions
Feb. 13	Full Moon
Feb. 14	Moon Apogee
Feb. 19	Poor EME conditions
Feb. 21	Last Quarter Moon
Feb. 26	Good EME conditions
Feb. 27	Moon Perigee
Feb. 28	New Moon
Mar. 5	Moderate EME conditions
Mar. 6	First Quarter Moon
Mar. 12	Moderate EME conditions
Mar. 13	Moon Apogee
Mar. 14	Full Moon and Penumbral Lunar Eclipse
Mar. 19	Poor EME conditions
Mar. 20	Vernal Equinox
Mar. 22	Last Quarter Moon
Mar. 26	Moderate EME conditions
Mar. 28	Moon Perigee
Mar. 29	New Moon and Total Solar Eclipse, Central Africa, Central Asia, and Central Russia
Apr. 2	Moderate EME conditions
Apr. 5	First Quarter Moon
Apr. 9	Moon Apogee and moderate EME conditions
Apr. 13	Full Moon
Apr. 16	Good EME conditions
Apr. 21	Last Quarter Moon
Apr. 22	*Lyrids* Meteor Shower Peak
Apr. 23	Poor EME conditions
Apr. 25	Moon Perigee
Apr. 27	New Moon
Apr. 30	Moderate EME conditions
May 5	First Quarter Moon and *Eta Aquarids* Meteor Shower Peak
May 7	Moon Apogee and moderate EME conditions
May 13	Full Moon
May 14	Poor EME conditions
May 20	Last Quarter Moon
May 21	Good EME conditions
May 22	Moon Perigee
May 27	New Moon
May 28	Poor EME conditions

—EME conditions courtesy W5LUU

Conference and Convention

Southeast VHF Society Conference: The 10th annual conference will be hosted in Greenville, South Carolina, April 28–29, 2006. The location and registration information were not available at press time. Please see <http://www.svhfs.org/> for the registration forms.

Dayton Hamvention®: The Dayton Hamvention® will be held as usual at the Hara Arena in Dayton, Ohio, May 19–21, 2006. For

(Continued on page 49)

Diversity Reception for Amateur Radio

WB9YBM discusses a "diverse" way of receiving amateur radio signals.

By Klaus Spies,* WB9YBM

Although diversity reception has been used for well over a decade in the commercial side of radio communication, it has been under-utilized (if utilized at all) in amateur radio. One reason may be due to the expense involved with the receivers, as a diversity receiver has two RF and IF stages, instead of just one each, which is typical of common receivers.

For those who are new to the concept of diversity reception, here is a brief explanation: The "diverse" part of "diversity reception" is a diverse antenna location. Instead of using the typical single antenna to receive a signal, two are used. They are spaced one wavelength apart, so that if propagation characteristics or signal-path changes from mobiles occur, signals will fade in at one antenna, while signals fade out at the other antenna. This way, a signal can still be heard. Making certain identical antennas, coax types and lengths, and receivers are used will ensure a fair and equitable chance that the signal will be received with the same chance at either antenna.

Here's how diversity reception can be realized in amateur radio without the need for expensive, specialized receiver equipment. In this example, the receivers available on your ham shack bench can be used—without even requiring modification!

Especially on the VHF and UHF bands, we've all noticed how signals swish-swish through signal nulls either when we ourselves are mobile and listening to our favorite repeater, or when we're trying to work mobile stations on simplex. In extreme cases, we've even lost a signal entirely, only to regain it by rolling our cars forward or back by a few feet.

Experiments in commercial application have shown that having two receive antennas spaced apart by one wavelength is the optimum distance between the two. In other applications (Nissan car radio antennas, circa 1990) when antennas were not spaced one wavelength apart, one was horizontally polarized and the second vertically polarized, which has merit if signals change phase due to path reflections (an example of this can be heard on 10 meters FM during band openings).

Because of the required antenna spacing, diversity reception is certainly easier on the VHF and UHF bands, particularly with

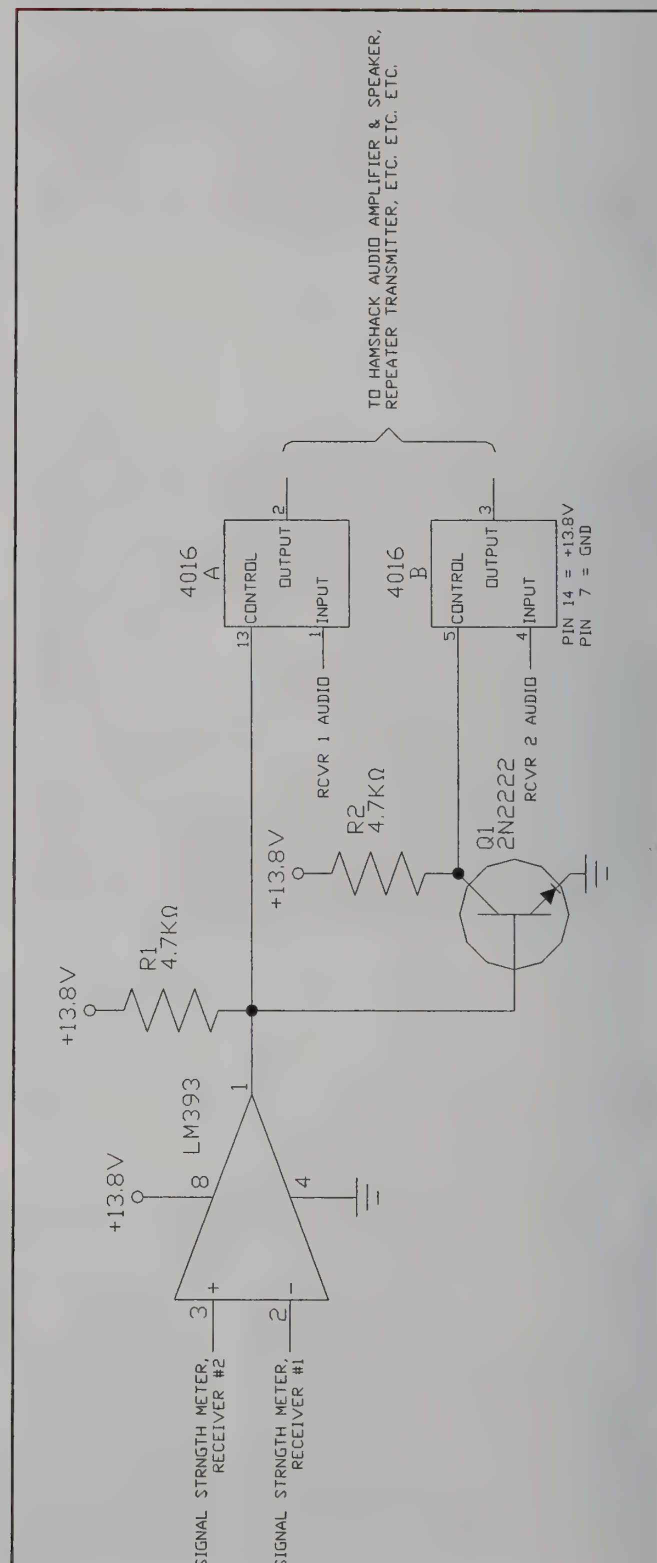


Figure 1. Schematic diagram of the circuit used for combining the signal-strength meters of the two receivers for diversity reception.

*815 Woodland Heights Blvd., Streamwood, IL 60107
e-mail: <wb9ybm@juno.com>

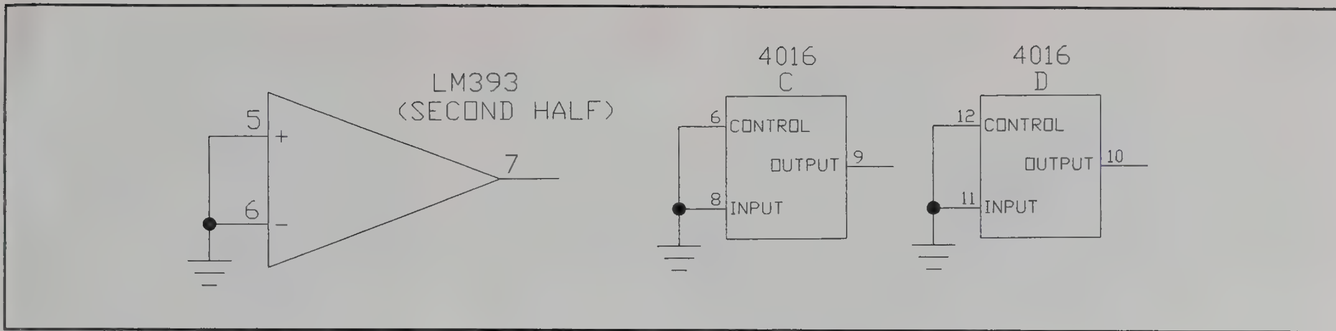


Figure 2. Schematic diagram showing the unused inputs of the gates.

the limited space in a mobile environment. It has been done successfully, though, on HF as well. In this particular case, I had a 10-meter FM to 220-MHz link established at a base station in Niles, Illinois with my friend Joe, W9CYT/SK, operating 10 meters FM in Schaumburg, Illinois, 30 miles due west of Niles. When stations faded out at Joe's QTH in Schaumburg, he heard them fade in at Niles, through the link. He could work DX without missing a beat!

With antennas now established to receive diversity, the next step is the radio aspect. Most people, especially those who have been around enough years to collect a bit of gear, typically have at least two rigs (if not more) for their favorite band. The only thing required of these radios is to tap a signal off the signal strength meter, and feed it into the circuit in figure 1.

When the signal strength at radio 2 is less than that at radio 1, the circuit will stay in the "off" position, and audio from receiver number 1 will be heard. Once the signal strength of radio 2 increases beyond the level of radio 1, the circuit will switch, and audio will be heard from that radio. The same can be applied to repeater operation, in order to make the machine more "bullet-proof" when operators are out near the fringe areas of the repeater's coverage.

There are certain considerations required to make sure we're playing on a level field: having identical antennas at identical heights will make sure we're hearing the signals with equal probability at both points. Identical receivers ensures both have very similar sensitivity and selectivity. These things will ensure that any switching that happens will occur due to a signal fading out in one antenna and fading in at the other, and not because one radio has an advantage over the other—and subsequently is forced to do all of the work.

Construction

In actual application, there are a few additional considerations required for proper circuit operation. Shielding the circuit in a grounded metal box, bypassing all incoming and outgoing leads, and using shielded cables—at least for microphone inputs—is the bare minimum protection against RF in the ham shack causing problems. Also, inputs of unused gates should be grounded (see figure 2).

Cross-Interference Issues

A question might be asked concerning protection of one radio from the other when the other is keyed: Does one need some sort of additional circuit to protect the first radio from being blown up (figuratively, if not literally) when the second radio transmits?

My answer is that no additional circuitry is needed. There might be ever so slight desensitization of a receiver if a nearby transmitter keys up, but that's only an issue for weak signals.

Conclusion

As built, the circuit provides switching speeds limited only by the response time of a radio's signal-strength-indication circuitry. If slower speeds are desired, small capacitors can be installed at the output of the signal-strength meters. ■

A Tale of Two Meters

Combine nostalgia for a radio once owned by the author with the opportunity to restore another radio of the same model, and you have the tale of how N9XU resurrected his interest in operating on the 2-meter ham band.

By Dave Holdeman,* N9XU

The past: It was the best of times. It was the worst of times. Shades of Charles Dickens' *A Tale of Two Cities,* and all that. Seriously, it was early 1974 and I was making good money as a supervisor for AT&T. The Middle East oil embargo was winding down, but there were still spot shortages here and there. It was at this time that I decided to drive up to Amateur Electronic Supply (AES) in Milwaukee and take advantage of a sale on 2-meter gear that they had recently advertised.

I took off for AES at 7 AM on a Monday morning, traveling from my home in Hanover Park, Illinois. Under normal weather conditions the trip should have taken no more than two hours, but I ran into a horizontally blowing ice storm en route that made driving nearly impossible. I arrived at AES at about 1 PM and bought an SBE model SB144—a 12-channel, crystal-controlled 10-watt transceiver with an S-meter, which doubles as a power output indicator.

Shortly after leaving AES, there was a power failure in the southern Wisconsin area, and I was unable to refill the car's gas tank for the trip home because of lack of power at the gas pumps. I was driving on fumes on interstate I-294/94 toward home with my heart in my mouth, and I heard on the car radio that electrical power had just been restored to Union Grove, Wisconsin. Luck was with me, as I spotted the Union Grove exit ramp just ahead. I reasoned that if the power was newly restored, there should be gasoline in town. Sure enough, I coasted into the first gas station I found and the station had plenty of gas. The proprietor said that I was his first customer since the power had been restored.

I arrived safely back home just before dark and installed the radio in my nearly new 1973 Mercury. About two weeks later the radio was stolen from my car before I had much of a chance to enjoy it. It was later recovered and turned over to my insurance company, but that's another story. It ended up being sold to another ham.

The Present (30 Years Later)

On May 2, 2004, I spotted an identical transceiver at the Dekalb County, Illinois hamfest. It carried a $35 price tag, which I thought was too high. About an hour later I offered the seller $10 for it (I'm not sure why, maybe nostalgia was affecting my brain), and he accepted my offer.

The next day I examined my purchase and noticed the following:

1. The rear power receptacle was broken and the positive lead was rubbing against the chassis.

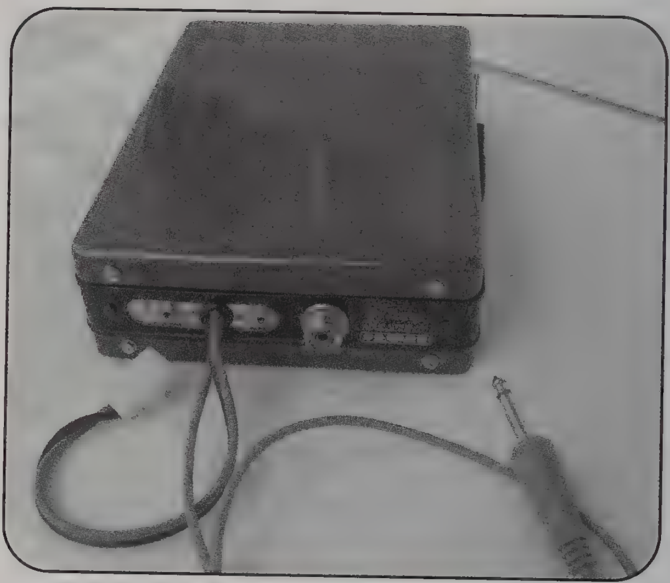


Photo 1. The broken power receptacle on the SB144 was replaced with a small metal plate and rubber grommet.

2. The top and bottom covers were scratched and the crackle finish was chipped in various places.
3. The top cover had four extra holes drilled in it.
4. The mounting bracket that came with the radio was not original.
5. The radio had no operator's manual.

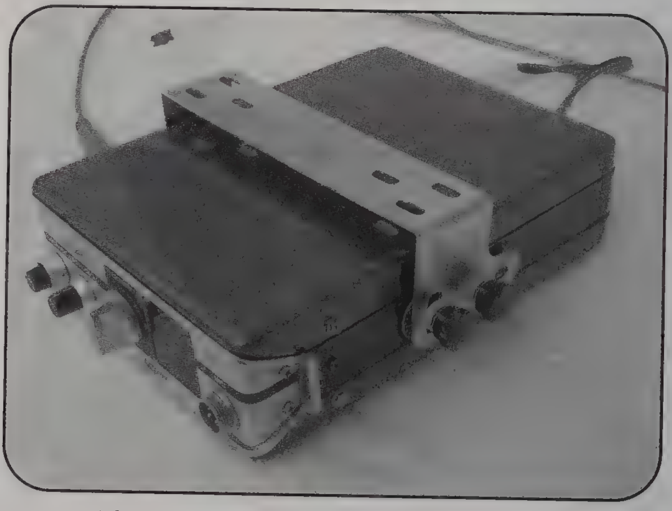


Photo 2. The mounting bracket arrangement

*e-mail: <d.holdeman@att.net>

Photo 3. The PL case assembly.

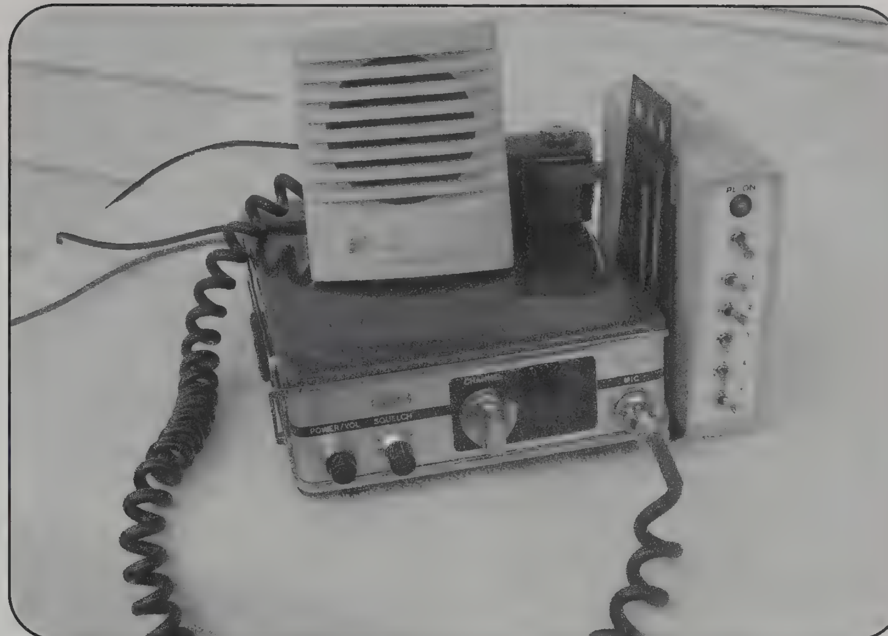


Photo 4. The renovated SB144 and the PL case look very attractive and make a nice addition to the shack.

6. The radio was equipped with six pairs of crystals, only four of which were useful in my area.

I performed an Internet search for an operator's manual and had five replies in about a half hour. Some had extra crystals, but they weren't suitable for this rig. Ed Lambert, K1ZOK, made me a nice, legible copy of his manual and an enlarged diagram, so it was easy to discern what modifications would be necessary to make the radio function in this modern age.

I replaced the broken power receptacle with a small metal plate and rubber grommet (see photo 1). Through the grommet I wired in a new power cable with a modern T connector. The rubber grommet was large enough to pass a small shielded cable alongside the power cable for connection to the phase modulator for the

insertion of sub-audible (PL) tones. I had an old Com-Spec 32-bit tone encoder in my junk box. After connecting the transceiver to my dummy load, I was happy to see that the power output measured between 10 and 12 watts.

I cleaned the unit with ammonia and cotton swabs and it started to look pretty spiffy. My son, who runs an auto-body shop, plugged the unwanted holes in the covers and painted them a nice charcoal gray using automotive enamel and clear coat. Since the covers use metric threads, I replaced the old grimy screws with shiny computer hard-drive mounting screws, which made a nice contrast with the charcoal gray. Now the unit looked better than new.

Before ordering crystals, I checked the output frequencies with my counter. The transmit crystals that were common to my area were put on frequency and the unneeded ones removed. Two receive crystals were off frequency when I used my synthesized handheld transceiver as a signal generator. I performed an Internet search for crystal manufacturers that were familiar with the SB144 specifications and placed an order on June 7, 2004.

Finally, I examined the mounting bracket that came with the radio. I found that it would work satisfactorily with the transceiver if I drilled two extra holes in it and used small felt spacers between it and the radio. I stripped the old finish from the bracket and found out that it was nicely plated underneath. It probably wouldn't have to be repainted at all. I most likely will never use the mounting bracket, but just in case, I tapped out the original threaded mounting holes in the sides of the radio from their original metric threads to 8-32 to match four knurled screws that I found at the local hardware store. They are called clamp screws, come in various sizes, and are quite attractive. The mounting bracket arrangement is shown in photo 2.

On July 21, 2004 I installed my new crystals in ascending order by frequency. I noticed that transmitting positions one and two were oscillating on the wrong frequency and were very unstable, although the power output seemed okay. I realigned the transmitter and that cleared up the trouble. I believe I had parasitic oscillations on those two channel positions.

There are three common PL frequencies used in my area. It therefore was necessary to come up with an arrangement to make the changing of PL frequencies easy. In order to do this I removed the tiny DIP switches from my junk-box PL deck and replaced them with miniature toggle switches. I mounted the whole shebang in a small modem case, bringing the toggle switches out through the front panel. At the same time, I added an LED to remind me whether the PL deck was on or off. Voltage for the PL was obtained from a regulated DC wall plug that I found at a surplus store. I then velcroed the PL case to an old metal bookend. The bottom edge of the book end fits under the transceiver, which holds the PL case vertical. The PL case assembly is shown in photo 3.

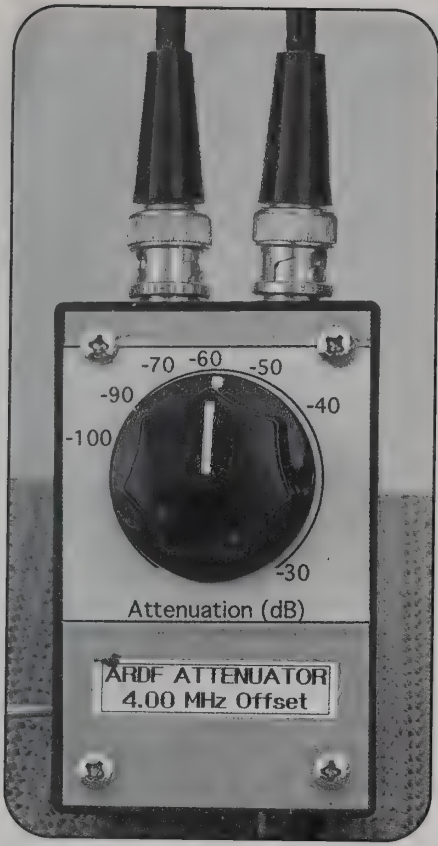
If one is adding PL to an old transceiver, it is normally good engineering practice to connect it to the modulator via the center terminal of the deviation potentiometer. I was unable to access the deviation pot, but was able to connect to the modulator transistor's base via a 10K series dropping resistor and a 1-mFd capacitor. I mounted these components in the PL case.

The SB144 is capable of 15 kHz deviation and has no automatic audio-level control circuitry. To set the deviation to approximately plus or minus 5 kHz I used the following setup: To the output of my scanner I connected a low-impedance VU meter. I then clamped the microphone of my synthesized 2-meter base station rig about one foot away from the speaker output of an audio oscillator. I connected the RF output of the synthesized transceiver to a dummy load and tuned the scanner and the synthesized rig to a frequency that is common to one of the transmit frequencies of the SB144. I turned on the audio oscillator, keyed the synthesized transceiver, and used the volume control on the scanner to set a reference value on the VU meter attached to the scanner. I then connected the SB144 to the dummy load and clamped the SB144 microphone in place of the synthesized rig's microphone. I keyed the SB144's microphone and adjusted the deviation potentiometer on the SB144 to get the same reference level on the VU meter attached to the scanner. I set the PL level by listening to the output of the scanner and backing it off until it was slightly below the audible point.

The radio looks like something out of the '70s (which it is) with its chrome-plated trim and shiny front panel. It and the PL case look very attractive and make a nice addition to the shack (see photo 4).

I have been using the SB144 when I run our local net and have gotten nothing but praise for its rich audio. The SB144 uses a frequency multiplication of 24, which probably contributes to good audio linearity.

One never knows what one might find at a hamfest. I just recently picked up a Regency HR2B, but what am I going to do with another 2-meter transceiver? ■



My home-built offset attenuator has been loaned to dozens of new radio-orienteers over the years at our local on-foot foxhunts.

was absolutely convinced of it, so I just went up and knocked on the door. When it opened, I said, "I know that this is a strange request, but do you own or manufacture any equipment that could cause radio frequency interference?" He said, 'We do GPS and satellite navigation systems, so it's quite possible. Come on in!"

After the Vice President of Engineering heard my story and listened to the noise, he got on the phone to an engineer in the back and asked him to turn the satellite link off. The noise went away. He turned it back on and the noise came back. "Well," he said, "we'll send that back to the manufacturer and have it fixed."

The interfering device was a radio modem and transceiver for communication with low-orbit satellites in the 148- to 150.5-MHz range. Its 5-watt transmitter was putting out an unstable spurious emission in the nearby 2-meter band. "The company had no idea what was happening," K6RBS said, "but they were very cooperative. The VP even offered me a job! He said he's been looking for a good engineering technician for some time. A ham who knows RF and troubleshooting would be ideal. I told him that as thanks for his cooperation, I'd put the job notice on our SOARA website."[1]

Jingling Spurs Everywhere

How many blockhouses full of commercial, government, and amateur radio installations are on hilltops in your area? Most of these transmitters operate under remote or automatic control for decades with no problems, but when one malfunctions, it sometimes is not apparent to the owners. Instead, it can become a mystery signal that affects other spectrum users.

The SOARA story brings to mind a similar transmitter malfunction a few years ago in Los Angeles. At that time, most open repeaters operated under carrier access, with no requirement for subaudible tones on the input. Users of these repeaters were used to occasional "kerchunks," but several repeaters began to experience frequent key-ups, often with snatches of medical-related messages in the audio. Monitoring on their input frequencies revealed that a spur from a paging transmitter was slowly sweeping from 146.4 to 146.2 MHz on every transmission, bringing up repeaters as far away as Running Springs in the San Bernardino Mountains.

Apparently, a lot of paging was going on, because there were a lot of these sweeps. It was worst in the late afternoon, making us suspect that the transmitter was in a room that got hot at that time of day, bringing on the spurs. While following the sweeping spur with one receiver, I used a scanner to check all the authorized paging frequencies for southern California. Exactly the same paging audio was on 171.3875 MHz, which was licensed to the Veterans Administration hospital in west Los Angeles.

After using RDF to confirm that the spur was indeed coming from that site, it was time to make contact and get the transmitter fixed. That's when my frustration began. "No problem," said the hospital's Communications Manager. "Here's the number of the dealer. We have a service contract, so just explain the problem and they'll fix it."

That sounded easy, until the manufacturer's representative told me that the contract only covered routine services. "This problem requires replacement of the transmitter, which the contract doesn't cover," he explained. "We sent the VA a memo to that effect."

At that point I became a reluctant intermediary in the middle of the dispute between a government agency, its radio service contractor, and the transmitter manufacturer. The hospital had no incentive to solve the problem without prodding, because its own radios and paging weren't being adversely affected. Administrators didn't seem to mind that their private medical messages were being retransmitted all over the southland. Thus, I had to keep calling the various players, getting responses such as:

Hospital Communications Manager: "We wrote a purchase order for the new transmitter."

Service Contractor: "We haven't gotten any purchase order."

Telecommunications employee replacing vacationing the Communications Manager: "There's no purchase order on file."

Hospital Communications Manager upon return: "The purchase order had an error and had to be rewritten."

Service Contractor: "Not only do we not have a purchase order, we haven't even been told to expect one."

Hospital Communications Manager: "The purchase order is rewritten and is probably in the signature chain."

Contractor's Receptionist: "He's out today."

Communications Manager's Secretary: "She's too busy to talk to you."

If a water pipe on my property sprang a leak, flooded my neighbor's yard, and began filling his basement, that neighbor would have no trouble getting local government to force me to stop the leak in minutes. Weeks of delay would be totally unacceptable. It wouldn't matter if I had a service contract dispute with my plumber or not. Similarly, one would expect that hams whose repeaters were being "flooded out" could get authorities to force the VA to fix its interfering trans-

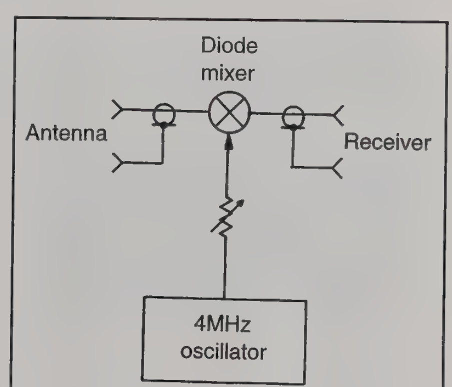
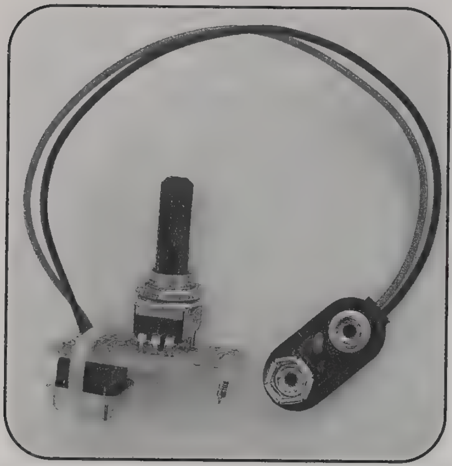


Figure 1. Block diagram of a simple offset attenuator. A potentiometer controls the amount of 4-MHz local oscillator signal into the diode mixer.



Marvin Johnston, KE6HTS, produces this offset attenuator circuit board with either a 2-MHz or 4-MHz crystal oscillator.

mitter immediately or shut it off. However, who's in charge?

What about the FCC? Yes, I tried there. The local Engineer-in-Charge told me that the FCC doesn't have licensing authority over government agencies, so he couldn't issue a notice of violation or intervene in any other way. He wouldn't bump it up the chain to Washington. Another dead end.

After many weeks the problem was finally fixed. Calls to doctors and nurses no longer rang out through southern California repeaters. This was before Riley Hollingsworth began handling ham interference matters in Washington. With that in mind, I wonder if a fix would come faster if the same problem happened again today.

Antidotes for RF Overdoses

Like the majority of 2-meter transmitter hunters in southern California, K6RBS uses a directional antenna and S-meter when tracking VHF spurious signals and hidden transmitters on foot. That requires some method for knocking down strong signals to the point that amplitude changes can be discerned as the antenna is turned. Front-panel RF gain controls are provided in only a few VHF transceivers, usually the relatively expensive multimode models. In most, lowering the RF gain control adversely affects S-meter action, so accurate bearings can't be gotten when gain is not at maximum.

It is possible to add internal RF gain reduction that won't upset S-meter action by controlling supply voltage to the RF preamp and first mixer stages, or by changing bias to FETs in these stages. I have done that with my faithful Drake UV-3 tri-bander for 2 meters, 125 cm, and 70 cm. That transceiver is easy to work on with multiple circuit boards and complete documentation. By contrast, it's difficult to perform similar electronic augmentation surgery inside today's tiny receivers full of surface-mount parts.

A simpler and much more popular way to knock strong signals down to size is to connect an external RF attenuator box between antenna and receiver input. A resistive (sometimes called a "passive") attenuator has several shielded sections in series, each with resistors to soak up the RF signal and a double-pole double-throw switch to bypass each section when not needed.

Attenuator boxes have been around for a long time and have plenty of uses outside of RDF work. You might find a good commercial one at a flea market, but check to make sure that no sections are burned out. You can readily make your own with ordinary carbon resistors, toggle switches, and copper-clad board.[2]

Most mobile T-hunters use these simple step attenuators. However, very strong signals will go around a resistive attenuator and enter directly through the receiver case or the coax between attenuator and receiver, pinning the S-meter. For on-foot hunts, when you may have to probe within inches of a transmitting antenna with a poorly shielded hand-held receiver, an offset-type attenuating system is better. It works by converting the strong on-frequency signal to a weaker and controllable off-frequency signal.

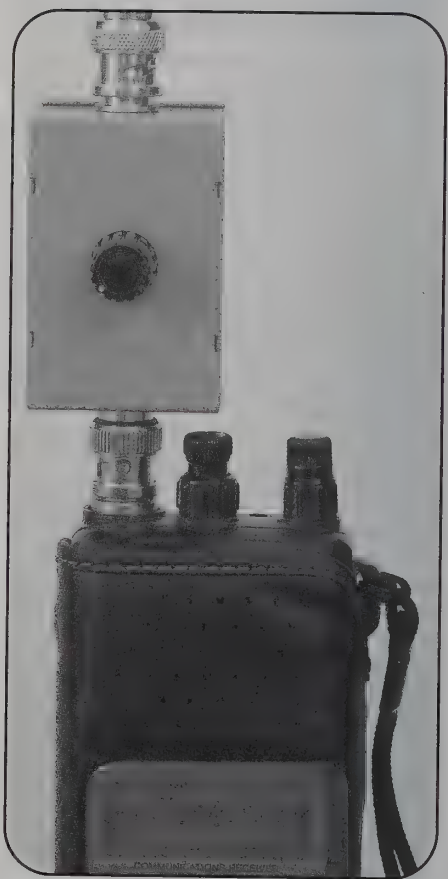
An offset attenuator consists of a local oscillator (LO) driving a diode mixer through the attenuation control, as in figure 1. The higher the LO level into the mixer, the higher the amplitude of the offset signal applied to the receiver from the mixer output. To increase attenuation, decrease the LO signal into the mixer with the control.

The most popular offset for 2-meter RDF is 4 MHz. For instance, to knock down a strong signal on 146.565 MHz, a popular simplex foxhunting frequency, turn on the 4-MHz LO, set the control for maximum LO into the mixer, and tune the receiver to 150.565 or 142.565 MHz. If the receiver does not tune outside the 2-meter band, use a 2-MHz LO instead and tune to 144.565 MHz. Reduce the LO signal until the S-meter is mid-scale and proceed with bearing-taking. The strong signal on 146.565 is still going into the receiver, but it doesn't matter because it's tuned to the offset frequency.

Some offset-attenuator builders use packaged double-balanced mixers, but a single, ordinary silicon diode works just as well for mixing in this application. I have measured up to 120 dB of effective signal reduction with one of my handheld receivers. Some receivers may not perform as well due to the effects of overload by the non-offset signal.

It is easy to find construction plans for offset attenuators on the web, including the popular version in my site.[3] It has a CMOS- or TTL-packaged square-wave oscillator powered by a 9-volt battery through a 5-volt regulator, giving consistent performance as the battery voltage drops. At the time I designed it, every component was available at RadioShack stores nationwide. Unfortunately, that's no longer true, so mail order is necessary for hams in the hinterlands who want to build it from scratch.

A good alternative for home builders is the partial kit offered by Marvin Johnston, KE6HTS.[4] On a small ($1^1/4" \times$



The Arrow Antenna offset attenuator box doesn't have labeling or calibration markings, but it's small enough to mount directly on the receiver.

Charles Scharlau. NZØI. sprints to the 2-meter finish line at the 2005 USA and IARU Region 2 ARDF Championships. He and his wife Nadia are the prime movers behind the next national championships in April.

3/4") circuit board are all parts except the RF connectors, battery, and enclosure. The board is so small that Marvin suggests building the attenuator into the handle of your RDF beam.

A new plug-and-play offset attenuator is being offered by Arrow Antenna.[5] Its small aluminum enclosure has a BNC male fitting on one end and a BNC female connector on the other, so it mounts onto the antenna port of many handie-talkies and scanners. Because the 4-MHz CMOS oscillator draws less than 2 milliamperes, Arrow claims that the supplied 3-volt lithium coin-cell battery will last 100 hours before requiring replacement. That's probably true, because the one I am testing has been loaned out on many local hunts and has not run down yet. I think I will add a test point so I can quickly check it with a voltmeter without opening the box.

In summary, an offset attenuator is excellent for on-foot foxhunting, whether you use it for "sniffing" at the end of a mobile hunt or for European/Asian-style in-the-woods radiosports. It works with directional antennas or just with a rubber duckie as an aid to the "body shield" maneuver.

On the other hand, a resistive attenuator is a better choice for mobile RDF in most cases. Passive attenuators avoid the possibility of images and re-radiation from mixer back to antenna, which is more likely in mobile situations than on foot. Also, you won't have to worry about the battery running down!

Medals in Your Future?

An offset attenuator, directional beam, and receiver are all you need to participate in 2-meter on-foot foxhunting under international rules, also called radio-orienteering and Amateur Radio Direction Finding (ARDF). Whether you're a beginner or an expert, you will be welcome at the 2006 USA ARDF Championships April 7–9 near Raleigh, North Carolina. If you are just starting, you will learn from the best. If you're already good at it, you might win a position in our national ARDF team, which will travel to Bulgaria for the 13th ARDF World Championships (WC) in September.

Because 2006 is a WC year, the USA Championships are in spring rather than summer, and are shortened to a weekend to minimize time off and expenditures for those who will take part in both the national and world competitions. Organizers are Charles (NZØI) and Nadia Scharlau, who have won medals at previous USA Championships and competed on Team USA at the WCs. They will be assisted by members of the Backwoods Orienteering Klub.

"At the 2006 USA ARDF Championships, competitors will be expected to provide their own lodging during their stay," says NZØI. "That is customary at most American classic orienteering events. Those who need transportation to and from the airport or the event site should contact us at the time of registration. We encourage all to stay at the suggested lodging. Having everyone housed in or near the same motels will make it easier to arrange for ride-sharing and will facilitate socializing.

"These championships will be ideal practice for those who hope to compete in ARDF internationally," Charles continues. "For beginners, this will be an excellent introduction to how this sport is played world-wide. The 'playing field' and 'referees' will be ready for all comers. Participants can customize their total experience by selecting their own accommodations, transportation, meals, and non-ARDF activities. Those looking for suggestions will find them on our web site[6] or by contacting us. The organizers and the Tar Heels of North Carolina welcome all to the 2006 USA ARDF Championships. We look forward to seeing you in April."

Registration for the USA Championships is now open and forms are at the abovementioned website. More information about the history, equipment, and techniques of ARDF is at my "Homing In" website.[7] Please continue to send me photos and stories of transmitter hunting in your area, whether for sport, interference resolution, or search and rescue.

73, Joe, KØOV

Notes

1. <http://www.soara.org/bbs/index.php>
2. Moell and Curlee, "Transmitter Hunting—Radio Direction Finding Simplified," Tab/McGraw-Hill, Chapter 6 <http://members.aol.com/homingin/THRDFSinfo.html>
3. <http://members.aol.com/joek0ov/offatten.html>
4. 408 Grove Lane, Santa Barbara, CA 93105 <http://www.rain.org/~marvin/k0ov.htm>
5. Allen Lowe, NØIMW, 911 East Fox Farm Road #2, Cheyenne, WY 82007-2588; telephone 307-638-2369, <http://www.arrowantennas.com/4ofha.html>
6. <http://www.ardf.us>
7. <http://www.homingin.com>

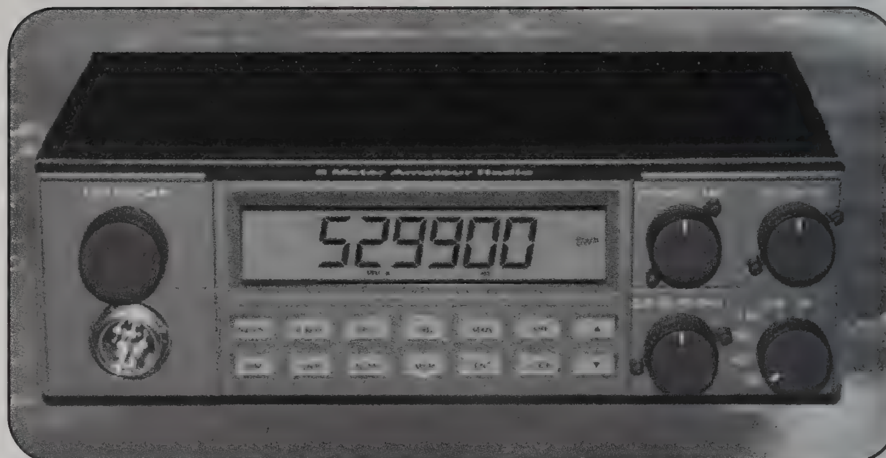
By Rich Arland,* K7SZ

BEGINNER'S GUIDE

All you need to know but were afraid to ask . . .

A 6-meter Rig and an Antenna Analyzer

Because this issue of *CQ VHF* will arrive during the winter 6-meter band openings, I decided to present a quick mini-review of a product that I have in my shack. Ranger Communications, Inc. (410 West 35th Street, National City, CA 91950; <http://www.rangerusa.com>) offers what I consider a good deal in a single-band VHF+ transceiver. The RCI-5054 DX-100 is a multimode 6-meter transceiver with variable power output up to 100 watts on SSB (50 watts on AM/FM/CW). The rig covers the complete 6-meter band from 50 through 54 MHz continuously while offering a 10-frequency memory, two programmable scan modes, and programmable repeater splits (for 6-meter repeater operation) up to 2 MHz. CTCSS tone encode/decode is optional.



The RCI-5054 DX-100 is a multi-mode 6-meter transceiver with variable power out put up to 100 watts on SSB (50 watts on AM/FM/CW).

This single-band rig is ideal for someone just getting started in ham radio via the Technician Class license, or for us "Old Timers" who need a rig parked on 6 meters to look for band openings while chasing the VUCC awards program. With up to 100 watts available on SSB and 50 watts on FM, the RCI-5054 DX-100 can provide reliable communications for local-area contacts as well as for some serious DX openings.

Six meters is not called the "Magic Band" for nothing. This unique portion of the spectrum offers great potential for local-area repeaters and simplex FM operation. You can get away from the congestion on 2 meters simply by using the RCI-5045 in the FM mode. Simultaneously, 6 meters can suddenly "open up" and you will be working DX on single- and multi-hop paths out past 3000 miles using the weak-signal SSB mode.

I love 6 meters just for this unusual combination of propagation enhancements. Having a single high-powered radio that I can dedicate to 6-meter operations allows me the luxury of not tying up the main transceiver just to monitor the occasional long-haul opening on 6 meters. The RCI-5054 sits quietly on the shack operations bench tuned to 50.125 MHz, the multi-mode squelch turned up to quiet the receiver, which ensures that I am not bothered by the constant background band noise. Should 6 meters suddenly experience a propagation enhancement such as a sporadic-*E* opening or a tropo ducting event, the squelch will open up as DX stations begin transmitting on the 6-meter calling frequency of 50.125 MHz. Life is good.

With the large, green, easy-to-read digital display it is effortless to QSY off the calling channel and start working stations. Controls are ergonomically laid out and easy to work. The receiver is very quiet and the all-mode squelch is a delight to use, quieting the receiver until something shows up in the receiver passband. This rig is well shielded, and in my TVI/RFI testing I have been unable to induce any of the five television sets in my home to misbehave in the presence of a 100-watt 6-meter signal.

The RCI-5054 DX-100 is at home in the shack as well as in the mobile or camper. Its relatively small footprint will fit most of the physical limitations encountered in today's automobiles. The RCI-5054 is a great addition to your Field Day arsenal. Newly licensed operators can have a station of their own centered around the simple-to-use RCI-5054 transceiver. Knowing that there is a solid 100 watts of RF output on SSB will be the confidence builder needed to help new operators garner QSOs during Field Day and VHF contests. Success is the key in developing and grooming new talent as future contest operators. For most hams, a quick tutorial around the RCI-5054 DX-100's controls is all that is needed to get them into the fray. After that, watch out! They will be hooked on contesting and Field Day.

As long as we are talking about neat things to have in the shack, next let me introduce you to a much-needed piece of test gear/shack accessory that I have come to rely upon constantly and really can't imagine being without.

The MFJ-269 HF + VHF/UHF Antenna Analyzer

Recently, a good friend of mine, Bill Rankin, WAØYPA, in Utah, contacted me and wanted to know what I would recommend as an antenna analyzer. His primary interests lie in 6- and 2-meter weak-signal operating. He was in the process

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of building some Yagi and quad antennas and needed a piece of test gear to optimize his designs. Without hesitation I told him to find an MFJ-259B. I had been using one for several years and really liked the unit, despite its voracious appetite for gobbling up "AA" batteries at a frightening rate.

One thing led to another, and Bill talked me out of my Model 259 (which I'd had ever since the "K7YHA North American Tour—1996," when I went out to play Field Day with the Zuni Loopers in southern California) in exchange for his father's old boatanchor station: Hallicrafters SX-117 receiver, HT-44 transmitter, the PS-150-120 power supply, and Turner +2 microphone. Bill got a great piece of test gear and I got my old college amateur radio club station (WA7CDH, Yakima Valley College) I had lusted for lo these many years!

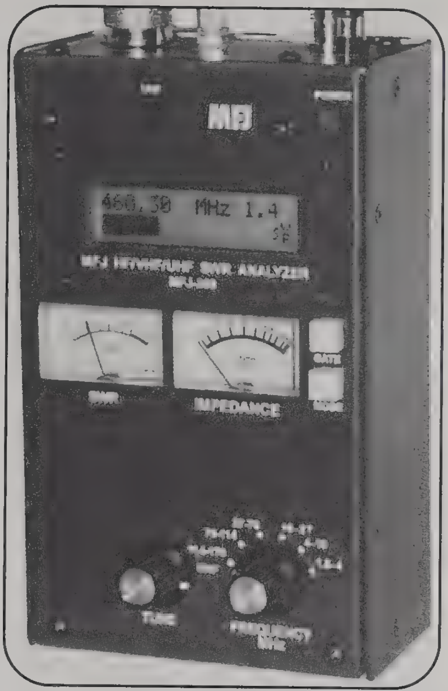
Now I was faced with a dilemma: I needed to replace my old MFJ Model 259 analyzer. A quick call to Richard Stubbs at MFJ and I had one of the new MFJ-269s on its way to me. The Model 269 is not only newer than the 259, it covers more spectrum. While the older Model 259 covered all of HF plus VHF up through 170 MHz, it was useless at UHF. The Model 269 has all the coverage of the older model, *plus* it covers 415–470 MHz, making it a great piece of test gear for not only ham radio antennas and installations, but commercial public-service/EMS installations as well! At last, I had a way to evaluate performance and adjust my 19-element UHF Yagi!

The UPS truck arrived a couple of days later with the Model 269. The first thing I noticed was that the internal battery pack had been redesigned, and while it was no easier to get into the unit to access the battery pack (you still have to remove eight screws), the new pack is made of sturdier material and utilizes one-piece construction rather than the two "four packs" of AA cells in the older Model 259. The dual meters will instantly show reflected power/SWR and impedance at a glance. The digital multi-line display reads out frequency along with capacitive and inductive reactance, phase angle, and a lot more. All this is just for starters!

MFJ really did their homework and provided the antenna experimenter with a valuable tool for a reasonable price. There is an optional carrying bag and coil set for testing tuned circuits and coaxial cables. The unit will function on internal batteries (10 "AA" cells for a 15-VDC input) or via an optional external "wall-wart" AC adapter. After a short time of inactivity, the analyzer "goes to sleep" to conserve battery power when on internal batteries. This is great, since it is a hassle to get the unit apart to replace internal batteries. Speaking of batteries, this unit has a built-in charger to accommodate rechargeable batteries as well as standard non-rechargeable alkaline AA cells. There is an internal switch that will defeat the charger circuitry so you don't end up trying to recharge non-rechargeable batteries, thereby avoiding the associated leakage and mess along with the distinct possibility of an internal fire!

The really nice thing about the Model 269 is that it is very portable, allowing you to drag it up on the roof, onto the side of the tower, or out to the mobile installation to check coaxial cables, tuning stubs, traps, baluns, and antennas right at the termination point. The multi-line display coupled with the various modes of operation can tell you a lot about your antenna installation and your feedlines. With it you can find shorts in a piece of coaxial cable.

You can also use this unit to measure and cut to proper length those pesky coaxial cable power dividers used to stack VHF+ antennas for added gain. Coaxial stubs got you down? Not anymore! The Model 269 will allow you to accurately measure and cut coaxial cables for matching purposes. Using the optional coil set you can make this unit function like the old grid-dip oscillators and use it to test tuned circuits in transmitters, antenna tuners, etc. Oh, yeah . . . Did I mention that the Model 269 also functions as a frequency counter up to almost 200 MHz?



The MFJ-269 antenna analyzer has all the coverage of the Model 259, plus it covers 415–470 MHz.

Well, it does! Talk about a versatile piece of test gear.

If you are an ardent antenna experimenter, then you *need* this antenna analyzer. Not only can you maintain your antenna farm in fine style, this unit is indispensable when it comes to ARRL Field Day and various VHF/UHF contests where you need to erect and trim antennas under field conditions, and for installing mobile equipment. Interested? Check out the MFJ website at: <http://www.mfjenterprises.com> for further information and pricing. 73, Rich, K7SZ

D-STAR
Digital Voice for VHF/UHF

VHF/UHF D-STAR radios are making their way into the U.S. ham radio community. What is this new technology and how will it benefit the ham radio enthusiast?

Digital Modulation

Unless you were unconscious for the last two decades, you have noticed that digital technology has swept through most types of electronic devices, creating more capability and changing primarily analog devices into digital wonders. Analog music media such as the conventional LP record and magnetic tape have been replaced by digitally-encoded CD-ROMs. More recently, the rise of the Internet and digital audio formats (e.g., MP3) has changed how music is created and distributed. Closer to home for ham radio enthusiasts, the cellular telephone, originally deployed with analog FM technology, has largely migrated to digital-modulation techniques. Digital technology allows mobile-phone service providers to provide cost-effective voice communications while adding services such as text messaging and web surfing, all while improving the spectral efficiency of their networks.

Meanwhile, those of us who enjoy using FM simplex and repeaters on the VHF and higher amateur bands are still using good old analog FM. Edwin H. Armstrong first described the use of *frequency modulation* in 1936.[1] The first practical two-way FM radio-telephone mobile system in the world was implemented in 1940 for the Connecticut State Police. Let's consider 1940 the start of what we know today as two-way FM radio. That was 65 years ago! Perhaps it is time to move to new technology.

We have already seen digital technology wiggle its way into our inherently analog radios. Modern FM transceivers have digitally-synthesized frequency control circuits, digital storage of channel information, serial ports for loading configurations, and computer software to control these rigs. Packet radio uses AX.25 digital protocols to provide an error-free data transmission mechanism, but the underlying modulation generally is still analog FM. The next step may be a truly integrated approach to voice and data.

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e-mail: <bob@k0nr.com>

Photo A. The ICOM IC-2200H is a conventional 2-meter FM transceiver with D-STAR digital operation available as an option. (Photo courtesy of ICOM America)

Digital Modulation in Amateur Radio

The Japanese government funded the development of the D-STAR standard, a digital radio format designed specifically for amateur radio. The Japan Amateur Radio League (JARL) administered the development of this open standard, and ICOM is the first equipment manufacturer to market D-STAR radios.

There are three distinct types of D-STAR transmissions with varying bandwidth required. The **DV** format is the narrowest modulation scheme, using a data rate of 4800 b/s to support simultaneous voice and data transmissions. Digitized voice is transmitted using 3600 b/s, leaving 1200 b/s for data transmission. D-STAR transceivers on 146 MHz and 440 MHz use this modulation format, since it results in a narrow 6-kHz signal bandwidth. I think of this mode as having a single voice channel, plus a digital channel similar to 1200-baud packet rates. This mode won't be great at moving large files, but it will handle lower speed data requirements. Photo A shows a 2-meter rig that offers D-STAR operation as an option.

The **DD** format is a *data-only* mode that provides a 128-kb/s transfer rate, occupying a bandwidth of 130 kHz. This mode is too wide for the VHF bands and is

Modulation Type	Band	Digital Rate
DV	146 MHz, 440 MHz, 1.2 GHz	4.8kb/s
DD	1.2 GHz	128 kb/s
Backbone	10 GHz	10 Mb/s

Table 1. Summary of available D-STAR modulation formats.

Photo B. The ID-1 transceiver is a 1.2-GHz transceiver that includes analog FM and D-STAR formats (DV and DD). (Photo courtesy of ICOM America)

offered by ICOM only on its 1.2-GHz rig. (The 1.2-GHz radio also offers DV format, as well as conventional analog FM.) Rounding out the D-STAR system is a 10-GHz backbone link that operates at 10 Mb/s. This radio link is intended for linking repeaters together on the ham bands without depending on any phone line or Internet connection. The data rates listed for these D-STAR formats are the nominal bit rates, but the use of *Forward Error Correction (FEC)* means that the actual throughput will be somewhat less.

I'll focus on D-STAR from the point of view of a typical FM ham radio user, most likely operating on 146 MHz or 440 MHz, using the DV D-STAR format.

D-STAR Technology

D-STAR is an open protocol, but one that was developed with amateur radio in mind. While being ham radio oriented, D-STAR still takes advantage of technology and standards from other communications industries.

Since D-STAR uses digital modulation, the analog voice signal is converted to digital format by an analog-to-digital converter.[2] These digital samples are further compressed by an AMBE® (Advanced Multi-Band Excitation) vocoder circuit. The vocoder takes advantage of the characteristics of human speech to compress the digital data stream into a much more compact set of data, minimizing the on-the-air bandwidth required. Vocoders vary in the quality of speech that they reproduce, and the AMBE vocoder gets high marks for speech quality.

The digital stream of bits goes out over the air using the modulation method known as 0.5GMSK (Gaussian Minimum Shift Keying). Roughly speaking, GMSK passes the digital input stream through a Gaussian low-pass filter which rounds off the edges of the waveform. This rounded waveform drives an FM modulator to produce the GMSK-modulated signal, resulting in a signal that is very efficient in terms of occupied bandwidth.

D-STAR transmissions are not compatible with the existing analog FM and sound like white noise when received on an FM radio. D-STAR radios provide backward compatibility with existing radios by including a conventional FM mode. The user selects whether he or she wants the radio to operate in analog or digital mode.

The D-STAR standard includes a position reporting feature that is similar to APRS®. D-STAR radios have NMEA interface for taking in position information from a GPS receiver. Basically, this data stream transmits the GPS coordinates at a time interval specified by the user. This transmission is *not* directly compatible with APRS, since APRS uses conventional packet radio, while the D-STAR information is encoded in the D-STAR digital format. Some hams are experimenting with gateways that pipe the D-STAR data into the APRS Internet System (APRS-IS), a collection of servers that track APRS reports.

Every D-STAR transmission has the station's callsign embedded in the digital stream. This makes identification automatic, sort of like Caller ID on a telephone. This enables other features such as "call sign squelch" so that you can monitor for transmissions from a specific station.

Repeater Systems

D-STAR supports a comprehensive linked repeater system. Repeaters can be linked together digitally either via the Internet or via radio on the 10-GHz ham band. When you transmit to a D-STAR repeater, your callsign is automatically registered with that repeater and shared around the D-STAR system. Each transmission contains routing information for where on the system the signal should be heard.

This may sound like a capability similar to the repeater linking that can be done using IRLP or Echolink®. These Internet linking systems use conventional FM over the air and convert to digital before sending the information over the Internet. D-STAR uses digital data throughout the system, including the initial RF link. The digital encoding in the signal makes the routing of signals from one repeater to another automatic, without the need for establishing (and later breaking) a communications link. In fact, D-STAR uses a different paradigm entirely, where each transmission is routed according to its embedded callsign-routing information. Since the signal routing is all digital, there will be no degradation of signal-to-noise ratio as the signal traverses the system. Compare this to repeater systems linked via analog methods, where each link tends to introduce a bit of noise.

D-STAR Benefits

Some hams look at D-STAR technology and get hooked instantly because it is new, cool digital technology. Of course, others ask the question "What is the benefit of D-STAR, as my analog FM rig works just fine?" Like most emerging technologies, the benefits of D-STAR may not be understood completely until the technology has been around for a while. The benefits of D-STAR fall into three major categories:

Spectral efficiency. The DV format of D-STAR has a bandwidth of 6 kHz, compared to 16 kHz for analog FM with 5-kHz deviation.[3] This implies that we could at least double the number of repeaters or simplex channels in a particular frequency band. Given that all repeater pairs in the 2-meter band are in use in many locations, this could have a dramatic impact on how the band is used. (Of course, this raises all kinds of sticky issues on how this change would occur. That is, existing repeater owners and users may not be motivated to change out their equipment.)

Routing information encoded in voice channel. The DV format has the transmitting station's callsign, the destination repeater, and other information

Photo C. The K5TIT rack of D-STAR gear includes (in order, starting near the top of the rack) a D-STAR repeater controller, 1.2-GHz voice repeater, 1.2-GHz data radio, 146-MHz voice repeater, and 446-MHz voice repeater. (Photo courtesy of Jim McClellan, N5MIJ)

encoded into every transmission. This encoded data enables automatic identification ("Caller ID"), selective calling ("Call Sign Squelch"), automatic logging of stations heard, and signal routing through a D-STAR repeater system.

Text and Position Messaging. Digitally-encoded position information can be sent, assuming a GPS receiver is connected to the D-STAR rig. The user can also manually enter the position information or a short text message. An external TNC is not required.

These benefits are from the perspective of an FM voice user. Clearly, D-STAR also offers other benefits for data-only radio use. In particular, the DD format offers the fastest turn-key digital radio baud rates for amateur radio use.

D-STAR Deployments

Not surprisingly, D-STAR usage took off first in Japan, with an unknown number of 1.2-GHz D-STAR repeaters on the air, all operated by the JARL.

This technology is in the early stages of deployment in the U.S., with a number of D-STAR pioneers trying out this new ham radio format. According to Ray Novak, N9JA, of ICOM America, there are approximately 15 D-STAR repeater sites on the air in the U.S., with three of them linked to the Internet. The activity on these three repeaters (and any others that add the Internet connection) is shown on the D-STAR users' website at <http:// www.dstarusers.org>.

The most active D-STAR group seems to be the Texas Interconnect Team, in the Dallas area, with club callsign K5TIT. This group has an active website devoted to D-STAR topics at <http://www. k5tit.org>. They have D-STAR repeaters on these bands: 146 MHz, 440 MHz, and 1.2 GHz (photo C). The group recently conducted the first U.S. field trial of ICOM's 146-MHz and 440-MHz D-STAR repeaters.

The Chester County Amateur Radio Special Interest Group (W3DES) in Chester County, Pennsylvania is a hotbed of activity on 1.2-GHz D-STAR, with several 1.2-GHz repeaters on the air.

New York City also has a 1.2-GHz D-STAR repeater in place. Rich Moseson, W2VU, the editor of *CQ* magazine, recently had the opportunity to use that system to talk with Jim, N5MIJ, on the K5TIT Dallas machine. Rich reports that the system worked well and the digital audio was "crystal clear." A recent article on the ARRL website (December 14, 2005: <http:// www.arrl.org/news/stories/2005/12/14/1/>) announced the deployment of a 1.2-GHz D-STAR repeater at W1AW. This machine was donated by ICOM and is being configured to connect to the Internet.

D-STAR is not just for repeaters, and there are a number of people out there running D-STAR 2-meter simplex. Since the digital transmissions are incompatible with analog FM, it is best to avoid any popular FM simplex frequencies. Most of the 2-meter D-STAR activity takes place in the "miscellaneous and experimental modes" section of the ARRL band from 145.50 to 145.80 MHz. There is no designated D-STAR calling frequency for use on a national basis, but 145.60 MHz, 145.61 MHz, and 145.67 MHz are often used. A recent poll on the ICOM D-STAR forums chose 145.60 MHz as an easy-to-remember D-STAR calling frequency.

Performance

When digital technology is used to transmit a voice signal and compression is used to minimize the required bandwidth, it raises questions about the audio quality. If the audio is not sampled often enough or the analog-to-digital conversion is too coarse, the audio quality can suffer. I have not used D-STAR on the air, but I have listened to recordings of D-STAR transmissions under varying conditions. John Habbinga, KC5ZRQ, recorded a weak-signal audio test using a mobile station and comparing DV audio and analog FM. This audio recording is available in MP3 format on the web at <http://www.lubbock-radio.net/D-STAR -vs-FM.mp3>. My impression is that with reasonable-strength signals, the D-STAR audio quality is very good, with just a hint of the digital vocoder "twang" that is common in digital cell phones. Reports from D-STAR users seem to agree with this assessment.

Like other digital-modulation techniques, D-STAR audio tends to drop out when in a fringe area, as opposed to gradually getting noisy like analog FM. If you listen to the KC5ZRQ recording, you will hear these dropouts when the signal gets weak. When John switches over to analog FM under the same working conditions, the signal is recognizable, but covered in noise. (Make sure you listen to the whole recording, since the weakest signal strength occurs near the end.)

Photo D. A photo of the ID-800H used for D-STAR experimentation by Pierre, AL7OC. (Photo courtesy of Pierre Loncle, AL7OC)

In his report on the Texas Interconnect Team field trial of the VHF/UHF repeaters, Jim McClellan, N5MIJ, writes:

> Range was excellent. The systems were simultaneously compared with a comparably equipped analog FM repeater, located at the same site. The nature of the digital signals used by D-STAR enabled us to have full copy in places where the signal of the FM repeater had dropped into the noise. There was no "noisy but readable" signal as you have on FM.
>
> Intelligibility was also excellent. Even at extreme range, voices are clear and readily identifiable. Voice quality is not as good as experienced on FM, but excellent for digital signals.

The June 2005 issue of *QST* has a great review of the IC-2200H mobile radio and the IC-V82 handheld rig, along with the technical evaluation of the D-STAR performance. (This is available online to ARRL members.) The ARRL performed a laboratory test of D-STAR weak-signal performance using a pair of IC-2200H 2-meter transceivers with the UT-118 D-STAR option installed.[4] They reported a similar result, but gave D-STAR the clear advantage over analog FM:

> We found solid, virtually noise free communication, equivalent to analog "full quieting" at any analog SINAD above about 6 dB. Note that while analog copy was usable at that level it was quite noisy, and a signal at least 10 dB stronger would be required for comfortable copy in analog mode with about 22 dB SINAD required for full analog quieting.

Keep in mind that this is a test on the lab bench in a controlled environment. It shouldn't surprise us if real world, mobile operating conditions produce a different result.

The narrower bandwidth (6 kHz) of D-STAR should provide an advantage over

the wider bandwidth of conventional FM (16 kHz), *all other things being equal.* Narrower bandwidth means there is less noise introduced into the receiver with which the signal has to compete.

Pierre Loncle, AL7OC, and Albert Noe, KL7NO, have been experimenting with D-STAR on 146 MHz and 440 MHz simplex around Fairbanks, Alaska. Using two ICOM ID-800H transceivers (photo D), they have compared analog FM and DV in a variety of conditions. Pierre reports:

> The coverage in deep fringe areas is slightly better in FM mode in that the human brain does a better job separating speech from noise than digital processors … if we lose our digital voice channel and switch to analog FM, the FM signal may still be copyable, but very noisy and of poor voice quality.
>
> We have also noted that the digital voice mode is more susceptible to interference from impulse noise … such as digital devices that are radiating a lot of RFI.

Thus we see some variation in the experiences that hams are having with D-STAR, which is to be expected with any new technology. The ham community will gain a better understanding of the fine points of D-STAR operating through experience.

The generally accepted method for specifying analog receiver sensitivity is *signal-to-noise ratio.* More precisely, the method used for analog FM is SINAD (signal-plus-noise-plus-distortion to noise-plus-distortion) ratio. The receiver sensitivity is specified as the signal level that produces a 12-dB SINAD ratio in the recovered audio. Digital modulation has the characteristic of being solid as long as the bits are received correctly, but has audio drop outs when the bits are corrupted. The analog methods of signal-to-noise ratio don't apply directly to digital modulation, and the preferred method for specifying imperfections in the signal is *Bit Error Rate (BER).* For example, the sensitivity specification for the ID-800H dualband D-STAR rig is BER 1% at <0.35-μV signal level. In other words, the receiver sensitivity is specified as the signal level where 1% of the digital bits are in error. This Bit Error Rate specification indicates the need for a different way of looking at amateur radio performance.

Barriers to Adoption

D-STAR clearly is an exciting new technology with great potential. However, any new technology has barriers to adoption. One potential barrier is cost, since a standard 2-meter rig costs about $160, while a D-STAR rig is about twice that. Recent prices on the Internet showed the IC-2200H 2-meter FM rig at $160 and the UT-118 D-STAR option at $200. It's interesting that the D-STAR option costs more than the 2-meter rig. Well, this is only one way to look at it. Another point of view is that for $360 you can buy a transceiver that does both good old analog FM and the latest emerging digital technology. Keep in mind that a basic VHF packet TNC costs about $180, so the UT-118 D-STAR option is similar in cost. Compare the cost of a D-STAR radio to a commercial radio capable of digital communications (APCO-25) and the D-STAR gear looks like a bargain.

Competition generally brings down the price of any product, so that raises the question of what do the other amateur radio manufacturers have planned? Clearly, ICOM is setting the pace in D-STAR equipment, with a complete line of VHF/UHF gear, including repeater equipment. According to Chip Margelli, K7JA, of Yaesu, Yaesu has no plans to offer D-STAR radio gear. The situation at Kenwood is less clear, since there have been sightings of Kenwood D-STAR gear in Japan, but Kenwood USA says there are no plans to introduce D-STAR equipment here. Perhaps more important is that as long as ICOM is the only game in town, it undermines the notion that D-STAR is an open, industry standard.

Another obvious barrier is the lack of repeater infrastructure. Most hams are going to be looking for some kind of repeater coverage in their area before spending extra dollars on D-STAR. Of course, this takes time. ICOM has offered a 1.2-GHz D-STAR for a while now, but repeater equipment for the more popular 146-MHz and 440-MHz bands is just now becoming available. The 146-MHz and 440-MHz repeaters in use at K5TIT are pre-production units, so we can expect to see this equipment available in early 2006. It will be interesting to see how many D-STAR systems pop up on the VHF/UHF bands in the next year or two.

Despite these barriers, D-STAR is a promising new technology. D-STAR is more than just digital modulation, as it provides a system approach to integrating voice and data communications. How the amateur radio community chooses to deploy this capability remains to be seen. Most likely, we can't envision all of the new applications that D-STAR will enable. Ray Novak, N9JA, sums it up well: "D-STAR is new technology. It opens up opportunities for new applications and features. This is fun!"

Wrap Up

For more information on D-STAR, see the web resources listed with this column, especially the ICOM website and the K5TIT website (both with online discussion forums on D-STAR).

My thanks go to these people for their assistance with this article: Ray Novak, N9JA, Division Manager – Amateur Products, ICOM America; Jim McClellan, N5MIJ, Texas Interconnect Team; and Pierre Loncle, AL7OC.

I've started a weblog at <http://k0nr.blogspot.com> that covers VHF/UHF ham radio topics, including D-STAR. Take a look and drop me a note there or to my e-mail address: <bob@k0nr.com>.

73, Bob, KØNR

Notes

1. Armstrong technical paper on FM (IRE): <https://michael.industrynumbers.com/fm.pdf>.

2. For a good overview of digital voice, see Doug Smith's article in January 2002 *QST.*

3. Via Carson's Rule, BW = 2 × (Peak Deviation + Highest Modulating Frequency) = 2 (5 kHz + 3 kHz) = 16 kHz.

4. "Installation and Test of UT-118 Digital Voice Modules," Michael Tracy, KC1SX, *QST,* June 2005.

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D-STAR Specification: <http://www.arrl.org/FandES/field/regulations/techchar/D-STAR. pdf>.

Texas Interconnect Team website: <http://www.k5tit.org>.

D-STAR Last Heard Page: <http://www.dstarusers.org>.

"Digital Voice: The Next New Mode?" Doug Smith KF6DX, *QST,* January 2002.Online at: <http://www.arrl.org/tis/info/pdf/0201028.pdf>.

QST Product Review, ICOM IC-V82 2 Meter Handheld Transceiver, *QST,* June 2005 (includes an overview of D-STAR operation). Online at: <http://www.arrl.org/members-only/prodrev/pdf/pr0506.pdf>.

"Digital Connection: D-STAR," Don Rotolo, N2IRZ, *CQ* magazine, February 2006.

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

The 1/4-Wave Whip

The classic 1/2-wave dipole antenna is shown in figure 1. The 1/4-wave ground plane uses the ground reflection to act as the other half of the dipole. Okay so far, but in photo A we have a small VHF transmitter from RF Monolithics®. That half-inch-square board is not going to act like a VHF ground plane; it's far too small. Therefore, a 1/4-wave antenna is simply not going to work well, as it's only half of the antenna.

When you feed a dipole antenna right in the middle, the feed impedance is about 72 ohms (figure 2). There are few fudge factors thrown in for the diameter of the wire, height above ground, whether or not there is insulation on the wire, etc., but 72 ohms is okay for this demonstration.

As the feed point is moved toward one end, the impedance increases, until near the end the feed impedance is close to 1000 ohms. A half-wave antenna is a great antenna. It's just hard to impedance match from the end.

Many of the simple single-chip transmitters or SAW (surface acoustic wave) oscillators are not really designed to drive a perfect 50-ohm load. Most are happy driving higher impedances. How high? Well, we really don't know in most cases. Also, the transmitter usually has switches, batteries, and other pieces hanging off the PC board. I have worked with over 50 different kinds of low-power transmitters, and I've never been able to calculate the best length for the antenna beforehand.

I start with a wire about 1/2 wave long and start snipping while measuring the transmitter's field strength (figure 3). With a few snips, the point where the transmitter impedance is happiest and the antenna is happiest is experimentally found. This is typically about .4 wavelength long. This is quite a bit longer than the typical 1/4-wave antenna, and I have seen as much as a 6-dB improvement.

For those of you who are designing the latest wireless device, trying to put a telemetry transmitter on a salamander, or stuffing a tracking transmitter into your model rocket, I think you'll find that a wire about .4 wavelength long will work a lot better than a 1/4-wavelength wire (photo B).

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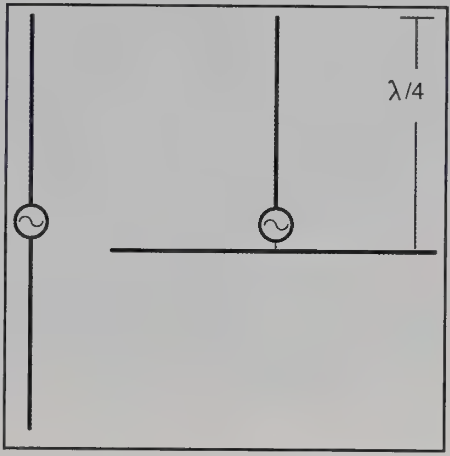


Figure 1. A 1/2-wave dipole and 1/4-wave over a ground plane.

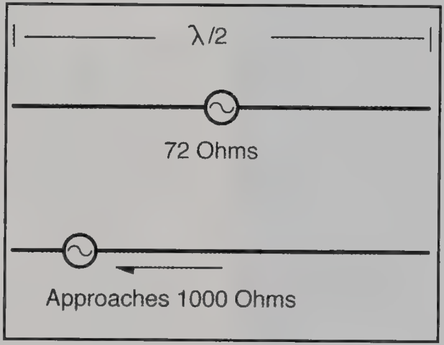


Figure 2. Impedance of a dipole antenna.

Other Radios

I look at my little ICOM Q-7 and I know that radio is not going to act like a 2-meter ground plane. This is why many hams often hang a 1/4-wave "tail" on the walkie-talkie to act as the other half of the dipole and boost its range. If you're playing around with a longer antenna, I think you'll again find that something near .4 wavelength is going to work better than a 1/4-wave whip. Many companies know this, and the antennas often are tuned expecting only a hand as the ground plane, but many aftermarket antennas are not.

Do you like to go backpacking with your Yaesu FT-817 or ICOM 703? Again, on HF you're going to find an antenna slightly longer than a quarter wave often works much better and is easier to match. I know my FT-817 isn't much of a ground plane on 80 meters.

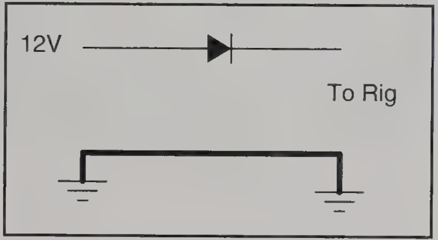
Reverse Polarity Protection

This is a bit off subject, but but N6CL, the editor of *CQ VHF*, is pretty open-minded about these things.

Just about all of my projects have a "reverse polarity" protection circuit, mainly to protect my projects from me! Many a time I've been working on something late at night and the red wire went to ground and the black wire went to power. Woops! I hate letting the smoke of out projects; it's so hard to get it back in.

Many, many years ago I worked my way though college as a bench tech in a CB shop. One poor trucker just couldn't get that red to red, black to black figured out. He blew out his reverse polarity circuit (figure 2) three times. This was really quite an accomplishment, since after the second time I replaced the 1-amp diode with a 20-amp alternator diode! I thus installed circuit 3 (see below), and don't recall seeing him again.

Let's go over the four common circuits, along with the advantages and disadvantages of each.



Circuit 1

Circuit 1. The big advantage of this circuit is simplicity. Just make sure the diode will handle the current. However, you have a .7-volt drop across the diode. Thus,

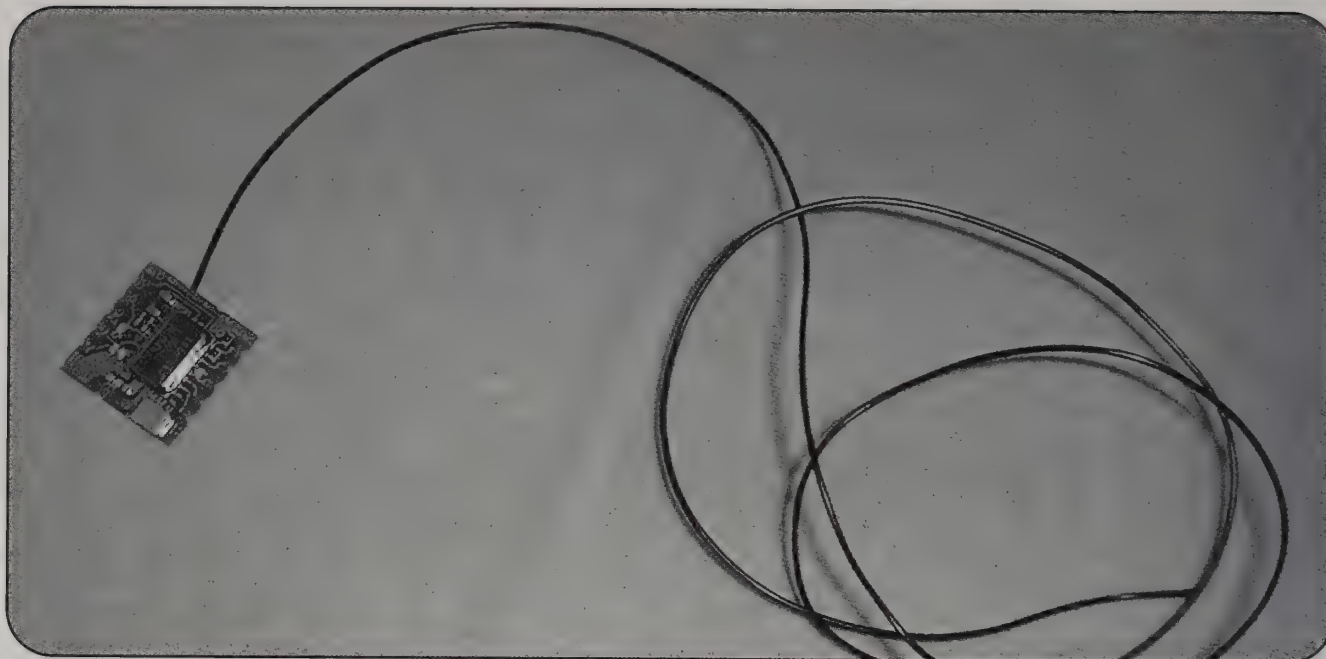


Photo A. Micro transmitter and antenna.

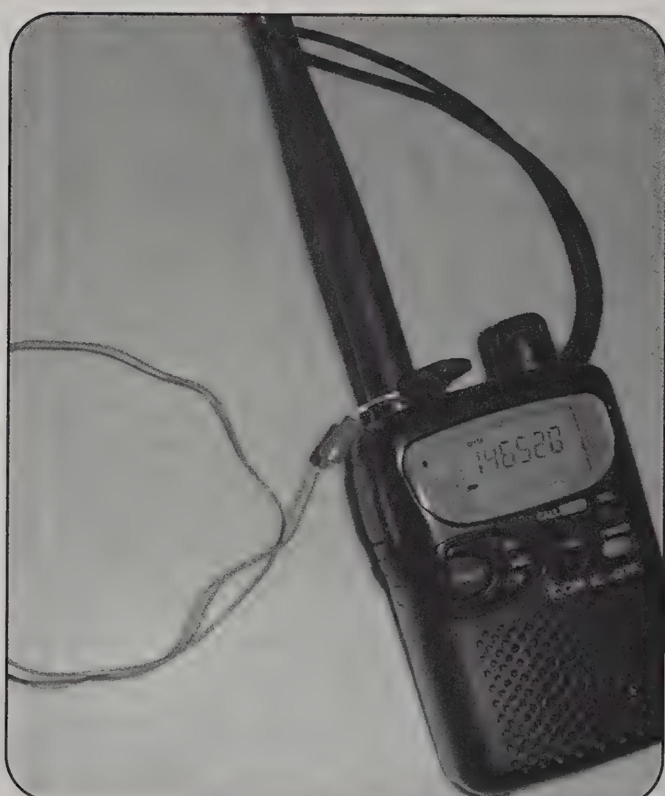


Photo B. Talkie with a tail.

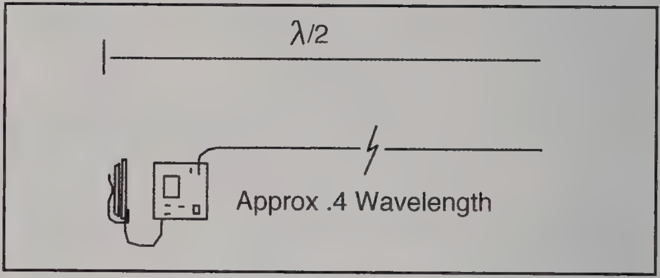
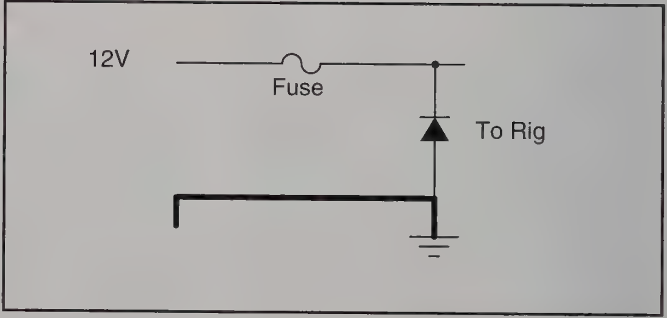


Figure 3. Transmitter and antenna.

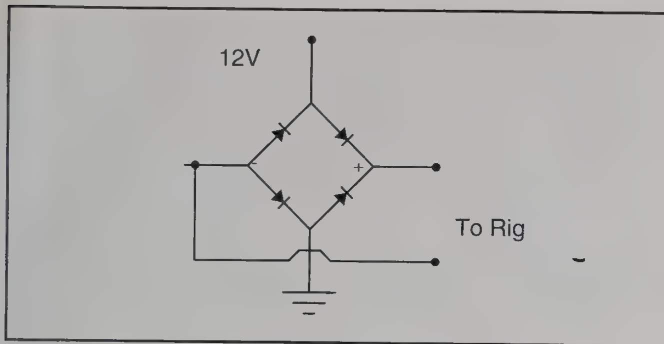
instead of 12 volts you have 11.3 volts. If the circuit has a 5-volt regulator, no problem. But if you put a diode in series with a 10-watt rig, it will drop to 8 watts out or so.

Circuit 2. Again this circuit is pretty simple, and this is the one used in most rigs for reverse protection. Normally the diode doesn't pass any current, but reverse the power and the diode looks like a dead short. A few thousands of a second later the fuse blows, protecting the rig. All this time the diode limits reverse voltage across the rig to .7 volt. The down side is that you have to have a fuse, and it had better be the right value for the rig. The trucker mentioned previously used a 35-amp fuse. Now it's not strange that he used the biggest fuse he could find, but 35-amp 2-AG fuses are hard to come by!

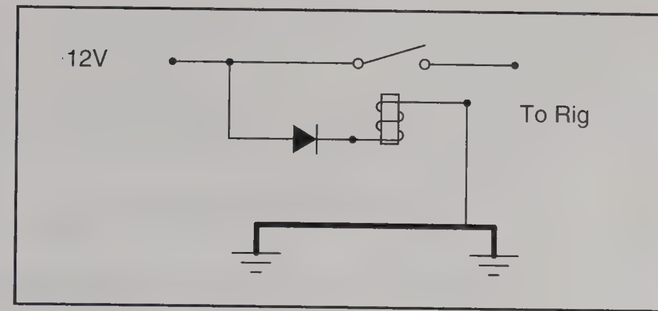
Circuit 3. A good old full-wave rectifier converts AC to DC, so no matter which way you connect the wires, the voltage comes out right. This circuit is especially good for those of you



Circuit 2



Circuit 3



Circuit 4

who like to use two green wires—one for plus and another for minus. However, now the current has to go though two diodes, giving you a 1.4-volt drop. Also, if the rig doesn't have an isolated chassis, the case could be .7 volts above with a negative-chassis car, or even 12 volts above ground with a positive-chassis car. Keep the metal parts isolated!

This circuit is what I put in that trucker's CB. His 4 watts dropped to about 2 1/2 watts, but as I said, I never saw him again.

Circuit 4. This is a popular circuit among UK microwave operators. If you connect the power correctly, current goes thought the diode, closes the relay, and power is connected to your station. If you don't hook it up right, and the rig doesn't power up. It's about as "idiot resistant" as you can get. It takes a few extra parts, and make sure the relay will handle your rig's peak current, but there is no voltage drop across a diode, making this the best reverse-polarity protection circuit.

Keep that smoke in your rigs. It's so hard to put in back in after that "oops!"

Civil Air Patrol

I was asked by a CAP lieutenant in California to develop a family of 121.5- and 243-MHz Cheap Yagis for CAP to use for ELT (Emergency Locator Transmitter) DFing. I came up with three 121.5-MHz and three 243-MHz versions. If we have a fair number of CAP members among the readership this could become an article, or perhaps it's something we should keep off-line. Let me know what you think.

As always your questions are a valuable source of inspiration for this column.

73, Kent, WA5VJB

Quarterly Calendar *(from page 25)*

more information, see <http://www.hamvention.org>. CQ Communications will have a booth in the arena, and N6CL is scheduled to be one of the speakers for the VHF forums.

Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers, or for papers to be published in the conferences' *Proceedings,* or both. For more information, questions about format, media, hardcopy, email, etc., contact the person listed with the announcement. The following organization or conference organizer has announced a call for papers for its forthcoming conference:

Southeast VHF Society (see conference dates announcement above): The deadline for the submission of papers and presentations is March 3, 2006. All submissions should be in Microsoft Word (.doc) or alternatively Adobe Acrobat (.pdf) files. Pages are 8 1/2 by 11 inches with a 1-inch margin on the bottom and 3/4-inch margin on the other three sides. All text, drawings, photos, etc., must be black and white only (no color). Please indicate when you submit your paper or presentation if you plan to attend the conference and present there or if you are submitting just for publication. Papers and presentations will be published in bound proceedings by the ARRL. Send all questions, comments, and submissions to the technical program chair, Jim Worsham, W4KXY at <w4kxy@bellsouth.net>.

Central States VHF Society Conference: The Central States VHF Society is soliciting papers, presentations, and poster/table-top displays for the 40th Annual CSVHFS Conference to be held in Bloomington, Minnesota (across from the Mall of America) on July 27–29 2006. Papers, presentations, and posters on all aspects of weak-signal VHF and above amateur radio are requested.

Deadline for submissions: For the *Proceedings*—May 1, 2006; for presentations at the conference and for notifying then you will have a poster to be displayed at the conference—July 3, 2006. (Bring your poster with you on the 27th of July.)

Further Information is available at the CSVHFS website: <http://www.csvhfs.org>. Also available are the following: "The 2006 Conference," and "Guidance for Proceedings Authors," "Guidance for Presenters," and "Guidance for Table-top/Poster Displays."

Contacts: Technical Program Chairman: Jon Platt, WØZQ, e-mail <W0ZQ@aol.com>; Proceedings Chairman: Donn Baker, WA2VOI/Ø, e-mail: <Proceedings.WA2VOI@OurTownUSA.net>.

EME Conference 2006: The EME Conference 2006 will be held in Wuerzburg, Germany August 25–27. Interested authors are invited to present a paper(s) for the conference. Electronic submissions in Word97, Word2000, Acrobat5 (PDF), or text format will be accepted by e-mail or CD. Please ask if you are using another format. If you are interested in writing and/or presenting a paper, send an e-mail to Rainer Allraun, DF6NA, at: <df6na@df6na.de>. Please contact him as soon as possible with an abstract or even a general idea. This will help the conference team with its planning activities. For more information about the EME Conference 2006 see: <http://www.eme2006.com>.

Meteor Showers

The α-*Centaurids* meteor shower is expected to peak on February 8 at 0500 UTC. The γ-*Normids* shower is expected to peak on March 13, and again on March 17. Other February and March minor showers include the following and their possible radio peaks: *Capricornids/Sagittarids*, February 1 at 1400 UTC; and χ-*Capricornids,* February 13 at 1500 UTC.

The *Lyrids* meteor shower will be active during April 19–25. It is predicted to peak around 1630 UTC on 22 April. This is a north-south shower, producing at its peak around 10–15 meteors per hour, with the possibility of upwards of 90 per hour.

A minor shower and its predicted peak is *pi-Puppids* (peak around 2130 UTC on April 23). Other April and May minor showers include the following and their possible radio peaks: April *Piscids,* April 20 at 1500 UTC; δ-*Piscids,* April 24 at 1500 UTC; η-*Aquarids,* May 6 at 0600 UTC; ε-*Arietids,* May 9 at 1300 UTC; May *Arietids,* May 16 at 1400 UTC; and o-*Cetids,* May 20 at 1300 UTC.

For more information on the above meteor-shower predictions see Tomas Hood, NW7US's VHF Propagation column on page 58. Also visit the International Meteor Organization's website: <http://www.imo.net>.

By Chuck Houghton,* WB6IGP

MICROWAVE

Above and Beyond, 1296 MHz and Up

Troubleshooting a 10-GHz Converter with a Homemade Noise Generator

My last column, in the fall 2005 issue of *CQ VHF,* covered the relay switching (transceiver) circuit I used for controlling the switching of my microwave converters. Who could have known that I would be trouble-shooting the switching circuits and the entire 10-GHz converter system? What happened follows, along with a description of a simple, homebrew noise head I used to trouble-shoot in my 10-GHz converter system. I will also cover how you can put together a noise head as part of your microwave test equipment.

Trouble raised its head while I was cleaning the shop shelf of my shack, where my 28-volt, 25-amp Astron power supply for my microwave converter's TWT (traveling wave tube) amp is located. I had removed the cover of the power supply while I was making an adjustment. Nearby was a stack of boxed stuff that had previously occupied the shelf. Shop cleanup created the setting for disaster. The 10-GHz rig was working just fine and was tuned to our microwave group's 10-GHz beacon on Mt. Miguel. The rig had just been moved. I was making a quick test of the beacon's signal quality, confirming system operation.

The next thing that happened changed the schedule for the day. I had to solve the problem in the entire 10-GHz system, from the power supply to the dish antenna feed. A metal pin rolled off the top of the pile of boxes where it had been perched and fell into the 28-volt power supply, shorting out the supply. Needless to say, I shut down the power supply and removed the pin ASAP!

I turned on the power supply, and you guessed it. . . . It appeared to have blown and the converter was dead. That started my day. A short beacon check ultimately became a full day of trouble-shooting a power supply, and at that point early in the day, who knew what else. I will describe the procedures I went through to determine what could be repaired.

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e-mail: <clhough@pacbell.net>

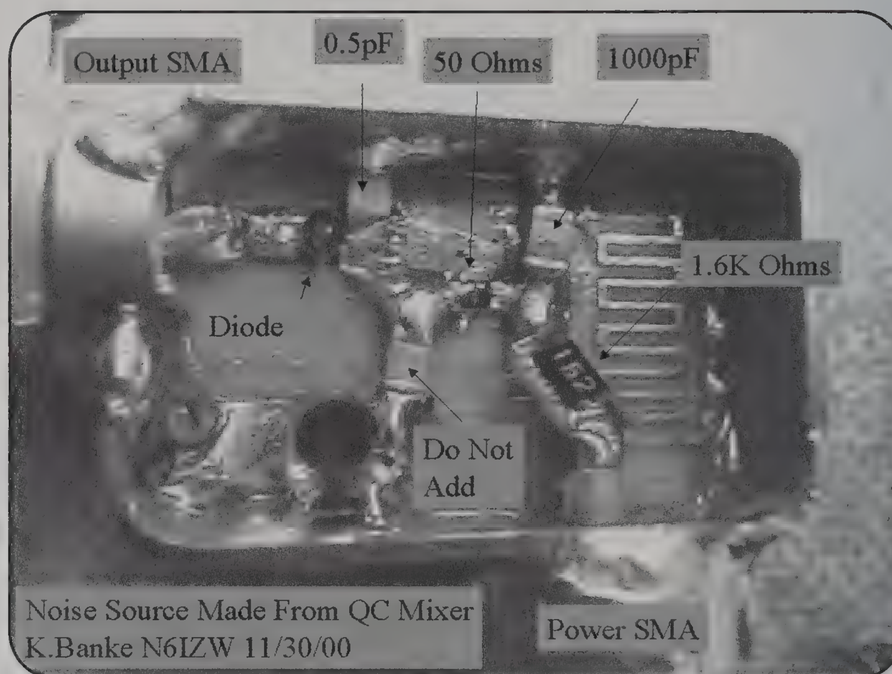

Photo A. Close-up of the surplus PC board and components as placed on the board.

At first, I was almost ready to go out and purchase a new Astron 28-volt LS 25-amp power supply. My supply is a heavy-duty analog supply and is very hefty. There are no meters or other panel controls and it is quite old, but it had worked for a long time. Ultimately, I decided to keep it and started trouble-shooting. With the AC line powered up, I checked for 28 volts DC. There was none. I checked the AC line fuse and it was okay.

I pulled the 35-pound supply from the shelf and put it on the workbench. I went through basic trouble-shooting procedures to verify the AC into the transformer. It measured 30 volts on the power supply to the filter caps through the rectifier stack. All was okay so far.

I then rechecked the DC output at full supply, and to my surprise there was 28 volts DC. I checked for any intermittent connections and found the negative test lead of my VOM had a loose banana plug. I fixed the plug. I next used a 100-watt 5.6-ohm resistor to load the supply. Testing with the resistor as a load verified that regulation would pull about 5 amps. The power-supply regulation was still putting out 28 volts with the test load. The power-supply trouble proved to be a defective test lead on the VOM. I then put the cover back on the power supply and returned it to the shelf.

Getting to the 10-GHz converter and TWT amplifier, I pulled inside the weatherproof case and microwave converter from the back yard for the 10-GHz station. The weatherproof case is an old BC221 frequency meter case that has sufficient space to house my converter and 10-watt TWT amplifier. The rig is constructed using a Frequency West brick local-oscillator microwave miniature mixer, transceiver relay switching with four SMA coaxial SPDT relays for IF, an

Photo B. The complete picture of the circuit board and SMA attenuators used for output load for the 5-dB ENR obtained on the unit N6IZW constructed.

RF amplifier for the TWT driver and a receiving four-stage FET pre-amplifier, TWT output switching, and main antenna receive transmit switching relay.

Powering up the converter, the first thing I checked was the Frequency West LO (local oscillator) crystal oscillator on its voltage test point, remote to the brick oscillator. It should have been about $^1/_2$ volt DC TOK (tested OK). Next I checked for lock between the crystal and high-power oscillator internal to the brick. Connection to the monitor lead from the brick should have been 4 to 10 volts DC on the phase "zero" monitor lead. Ideally, it should have been midrange, about 7 volts. I readjusted the cavity to obtain 7 volts DC, adjusting the cavity slightly on the high-power internal oscillator. It tested OK. Now that left a two-stage RF amp used in both receive and transmit, a four-stage LNA pre-amp for receive, relay switching, and about 15 miniature 141 hard copper microwave low-loss coaxial-cable connections.

Also, where I feared to tread is on all the low-voltage power supplies for all the pre-amps and other circuitry. They are the +10 VDC, –5 VDC bias supply, an isolated 28- to 12-volt positive ground supply, and a 12-volt negative volt supply that had to be used—as the TWT is a positive grounded system, as is the main LO, a brick oscillator operating with –19 volts at $^1/_2$ amp with the crystal heater.

What's the best choice of test equipment you can use to find the trouble? I usually prefer a signal generator on the frequency of the device being tested. That can be troubling, as it could require several generators to test the IF and RF circuitry. The generators also require the test-frequency source to be very stable. As with SSB bandwidth used on modern narrow-band converters, you have a window of 2 to 3 kHz to find your test sig-

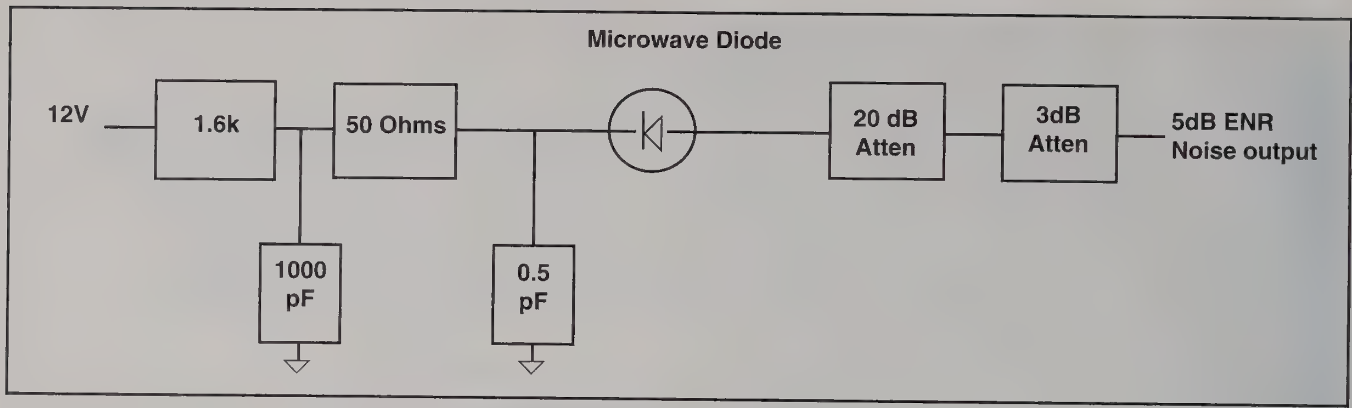

Figure 1. Diagram for the 5-dB ENR (estimated noise reduction) noise source based on surplus Qualcomm 14.5-GHz mixer board. (Courtesy Kerry Banke, N6IZW)

nal. If you don't have a very stable generator, a simpler device can be used—a simple diode connected as a noise generator. If the diode generator circuitry is kept very small, it will have great noise output in the high microwave region, usually just fine at 10 GHz.

Look at web page <http://www.ham-radio.com/sbms/sd/>. Look for tech notes from the SD Microwave group for details on building your own noise generator, specifically an article by Kerry Banke, N6IZW. Yes, a commercial noise power supply and noise head could be used, but they are precious devices and should be used carefully. One error, such as transmitting into one, will destroy the "good stuff," a calibrated noise head.

This article will show how a surplus diode that we had in the junk box, plus a few extra components we had on hand, including the PC board, can be used to construct a noise head.

The reason for using a noise generator is simple: It generates noise that can be received on an SSB system from very low frequency (10 to 50 MHz) to 10 GHz, and might even go higher depending on construction. The noise-head diode operates in the zener reverse-voltage region of the microwave diode, limited in current to about 1.5 ma. With the internal 1.6K-ohm series resistor powered with 12 volts DC, you can turn on and off the +12 volts to pulse the noise head on and off. If you have a 28-volt noise figure meter, insert a 22K-ohm resistor in series with the 1.6K-ohm resistor to limit current to 1.3 to 1.6 ma of current. You will have to tinker with the exact value of the resistor value to obtain maximum noise at 10 GHz, or the frequency you are interested in.

The 50-ohm resistor should be a good-quality chip ceramic resistor, but the 1.6K- or 22-K-ohm resistor can be carbon 1/4 watt or even 1/8 watt if you have one. There is nothing fussy here, as the board supplied for this project has two diodes, three of the .5-pF chip capacitors, and two brown miniature chip caps used for bypass on the DC input. I measured the brown bypass caps to be .001-µFd chip caps as on the supplied miniature PC board.

Using the noise head, I connected the head and a 20-dB SMA pad to the RF in the 2-meter multimode receiver. I applied negative ground and +12 volts to the noise head. You should hear white noise increase when keyed with +12 volts DC. In my case, I applied the noise head to the IF cable to a 2-meter IF receiver, and the generator was quite loud. I used an old Kenwood TS700A 2-meter multimode receiver transmitter equipped for SSB. It tested OK here now. I next applied noise to the mixer RF input (IF output SMA) connected to the TS-700 2-meter Kenwood SSB receiver. It was dead—no noise. I checked the LO output from the Frequency West brick oscillator. Using a Hewlett Packard power meter with a 10-dB pad should give a measurement of at least +10 dBm. If you have a frequency counter at 10 GHz, verify frequency of the LO required for a 10-GHz and 144-MHz IF system.

Mine was okay. I changed out the 10-GHz mixer. This turned out well, as now noise from the mixer input (RF port) to the system's IF transceiver was working. I next moved the noise generator to the main antenna RF in/out connector and confirmed that the noise was good here, too,

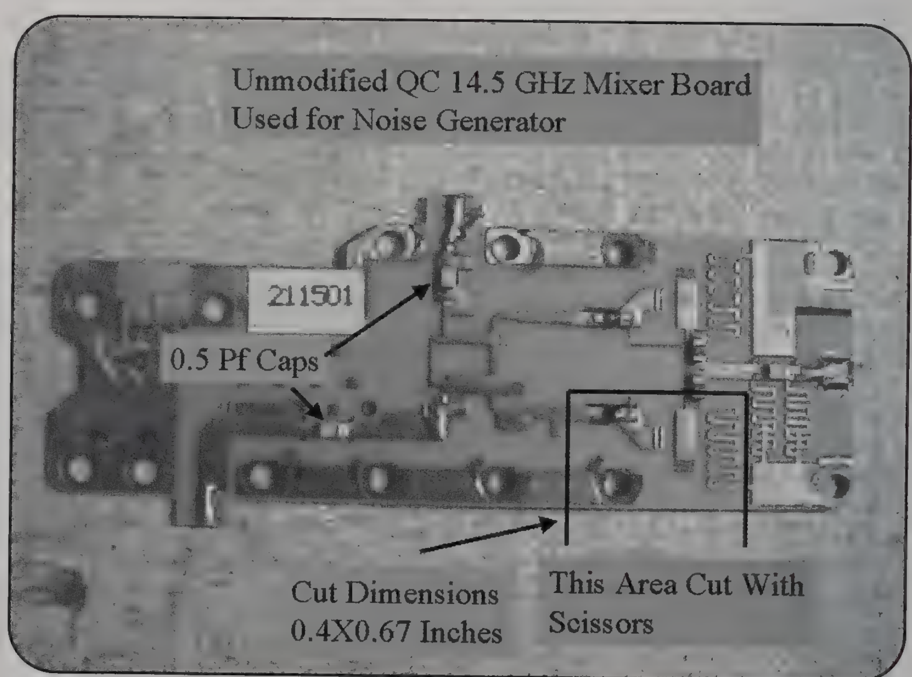

Photo C. The complete surplus PC board before it was cut to size for noise-figure construction.

with the system back in service. Don't ask why the mixer blew and did not affect the pre-amplifiers, as they still worked okay. I just lucked out with the mixer I had as a spare in the junk box. I refer to such microwave mixers and associated parts as piece of "unobtainium." When I find myself at a swapmeet and locate such items at bargain prices, I pick them up for future use such as this. Always save such parts for that rainy day. I just happened to have a few spare mixers in the junk box that were bargain purchases at our local swap meet.

Last but not least, I checked the output on transmit and connected two each 2-watt 10-GHz rated attenuators for additional 40 dB loss. I turned on the transmitter and got a reading on the power meter of slight negative movement, or meter vane, say –0.2 dBm with 40 dB attenuation in series to the meter. That confirmed that the TWT amplifier output was slightly less than 10 watts on 10 GHz. I then shut down the transmitter and TWT.

I next connected the commercial noise head to the RF input to the converter system RF input. With my noise head and 20-dB attenuators in noise connection to the converter, I saw the system's S-meter wiggle and heard the noise pulsing, verifying to my satisfaction that the entire system was operating well. The final confirmation occurred when I attached the converter to my back-yard desk and copied the beacon quite well. It was 10 dB over S-9 using an old S-meter on the Kenwood TS-700A. All this happened after not following the basic premise "keep the junk under control."

The noise head was constructed to keep components tight, and was built on a postage-stamp-size section of Teflon® PC board scrap that previously housed a 14-GHz mixer. The diode and 0.5-microwave-rated chip cap and the PC circuit board were recovered from local scrap and will be made available from the author. The remaining components are a quarter-watt resistor and two SMA pads, which serve as microwave-frequency-rated load for the noise diode. The noise diode is back biased at 12 volts input for 1.6 ma current). A small metal box with two miniature SMA coaxial connectors and a feed-through cap for DC feed finish the parts count for the noise head.

This project is quite simple. The photos tell the story, and the components to construct the noise head are quite easy to obtain. The most difficult thing for me in the construction was holding the miniature chip components in one spot to solder them in place. Try using a drafting variable-width pen tip used as a variable-width clamp to hold the miniature chip capacitor and then tack-solder one end of the component in the exact place. Component placement is not critical, and the only fault of larger construction techniques is poor performance at higher microwave frequency. Yes, the noise is not calibrated, but it will provide you with a very simple indication of go, no-go operation of your microwave system, one which will fit in your pocket, is simple to construct, and is quite inexpensive to put together.

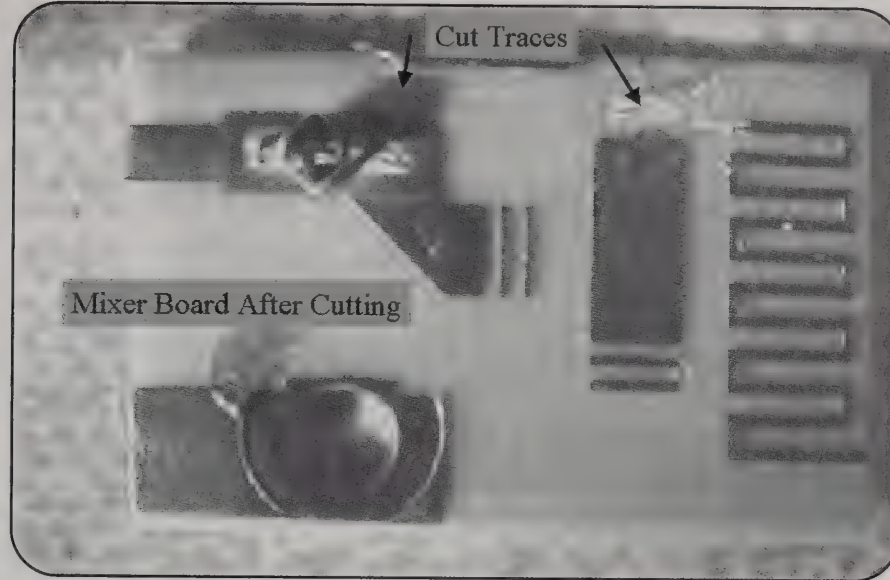

Photo D. The PC board ready for construction of the noise-figure generator.

I could not find the original noise head I had constructed, so I assembled another one to not only work at 12 volts DC, but also at 28-volts DC for my bench AIL 1415 automatic noise-figure meter. The unit I constructed came close to specs on my commercial head.

I would like to thank Kerry Banke, N6IZW, for his design and the photos used in this article. Again, for further details, look at the web page of the San Bernardino Microwave Society (SBMS) at <http://www.ham-radio.com/sbms/sd/>. Look under tech articles from the SD Microwave Group (top of the list) and go to the noise generator by N6IZW.

To facilitate your building the generator, I am making available PC boards with two diodes on each board. They are $3.00 each postpaid, or three boards for $7.00 postpaid. I am trying to locate a supply of .001-µFd chip caps and 50-ohm resistors for this project. If I can find them in surplus, I will include them in the kit. Always try to keep cost at a minimum. Orders for kits with board go to: Chuck Houghton, WB6IGP, 6345 Badger Lake Ave., San Diego, CA 92119.

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

An Update of the World of Satellites

Since the last column, SSETI has been launched along with its fleet of CubeSats; the AMSAT Board of Directors met in Pittsburgh, PA; the Project EAGLE Team met in Pittsburgh, PA; SuitSat deployment is "slipped" until February 2006; and Expedition 12 is *very active* on the ISS. All of the popular "LEOs"—AO-51, AO-27, AO-7, SO-50, FO-29, GO-32, and VO-52—remain active. AO-51 carries on its multi-mode operation/experimentation, and VO-52 has tested its Dutch Transponder successfully.

SSETI Express (XO-53)

The SSETI (Student Space Exploration and Technology Initiative) project has been discussed in some detail in recent columns, so details will not be repeated here. After a series of earlier launch schedule "slips," at last press time the hardware and launch team was in Russia securing the equipment and going back home to wait after another "slip." Launch finally occurred on October 27, 2005 at 06:52 UTC on board a Kosmos 3M rocket launched from the Plesetsk Cosmodrome in central Russia. It was designated XO-53 by AMSAT by request of the SSETI team and was assigned the NORAD ID 28894.

Shortly after launch, SSETI deployed three CubeSat pico-satellites developed by universities. After launching the CubeSats, XO-53's batteries stopped charging and the spacecraft went silent. The control team is hopeful that recovery will be possible, but as of press time there has been "no joy."

If/when XO-53 is recovered, it will also function as an amateur radio transponder for the remainder of the mission. SSETI can also downlink Earth images and demonstrate technology for the European Student Earth Orbiter. Most of the educational goals planned for SSETI have already been realized by the construction, launch, and initial operations, so the mission is already a success.

The three CubeSats deployed by SSETI Express and their status are:

- **XI-V** from Japan, University of Tokyo: Alive and well.
- **UWE-1** from Germany, University of Würzburg: Alive and well.
- **Ncube-2** from Norway, Andoya Rocket Range: After an initial period of about two months without any confirmation of deployment or operation, evidence of probable deployment has been discovered; however, there is still no evidence of operation.

AMSAT BoD Meeting 2005

The 2005 AMSAT Board of Directors Meeting and the 2005 AMSAT Annual Meeting were held on October 6–7 in Pittsburgh, PA. The entire BoD, as follows, attended. Incumbents re-elected are Rick Hambly, W2GPS; Barry Baines, WD4ASW; and Gunther Meisse, W8GSM. New to the board is Emily Clarke, WØEEC. First Alternate is Bob McGwier, N4HY, and Second Alternate is Lee McLamb, KU4OS. Returning BoD members for their second year are Tom Clark, W3IWI; Paul Shuch, N6TX; and Lou McFadin, W5DID. Officers were elected for the following year. The only major change was the replacement of Stan Wood, WA4NFY, by Bob McGwier, N4HY, as Vice President of Engineering.

Complete minutes of the BoD meeting will appear in the *AMSAT Journal*. Reports were given on all operational functions of AMSAT, with major emphasis on budget and plans for the future. Fund raising for major projects such as EAGLE occupied a major part of the time. Gunther Meisse outlined an organized, professional fund-raising effort that prompted much discussion, but ultimately met with approval. Elements of this effort are already in place. Educational outreach was another "hot topic," along with emphasis on the "open source" concept for current and future projects. The place for the 2006 AMSAT Space Symposium was set for the San Francisco Bay area in October 2006.

The AMSAT Annual Meeting was held on Friday evening, October 7, 2005, with those present meeting in the hotel, and for the first time those not present were invited to join the meeting via Echo Link. This method of operation worked well and probably will see much more use in the future. Total attendance was approximately 30 in the hotel and another 30 from around the world via Echo Link.

Project EAGLE Meeting

Two Project EAGLE satellites will fulfill a major part of AMSAT's vision of 24-hour coverage by high-altitude satellites by 2012. The Phase IIIE satellite being developed in Germany will fulfill the first part of this vision. On October 7–9 the program shifted gears for a Project EAGLE Meeting. Additional team members arrived to support the meeting chaired by Project Leader Jim Sanford, WB4GCS.

An overview of the EAGLE architecture developed so far was presented as a starting point for this meeting. Features of this architecture are a software-defined radio based transponder for traditional modes and the C-C Rider concept, introduced by Tom Clark, W3IWI, for expanded-mode coverage at C band. These modes were discussed at length, and initial steps were taken to identify and document the interfaces necessary to support these modes. A paper was presented on the structural aspects of the satellite, and some new, very interesting concepts for power generation and control were presented. These activ-

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ities filled the time allotted on Friday and Saturday, except for the social event Saturday evening at Jim Sanford's house. Sunday morning was filled by discussions of the RF requirements for the satellite and a very inspirational discussion of concepts for an EAGLE Ground Station.

As an interested "outsider" (not a member of the team), this was a very interesting and encouraging meeting. The meeting was well run, and concepts were well thought out and challenging, but practical. Significant progress is being made on all fronts. The design is being documented as it develops, and under the "open source concept," it is being shared via the AMSAT web page. The largest challenge by far is fund raising, and this topic was amply addressed at the AMSAT BoD Meeting. AMSAT members and the public will be hearing from fund raisers soon. Please support this worthy effort!

A follow-up meeting on RF design was held in New Jersey over the Thanksgiving holiday weekend. The list of attendees reads like a "Who's Who" in amateur radio RF design. Assignments were made, lab space was defined, and the team is "charging on."

SuitSat

SuitSat was to be deployed in December via an EVA (extra vehicular activity); however, the schedule slipped and deployment is now scheduled for February 2, 2006. It may already be history by the time you read this, but it bears mentioning again. Watch the AMSAT News Service and the AMSAT and ARRL web pages for updates on both of these items. Links to complete articles on SuitSat are available on the AMSAT web page. An excellent report on SuitSat hardware was presented by Lou McFadin and Steve Bible at the AMSAT BoD meeting. The SuitSat Project will be of great interest to school kids (and older kids as well). Get your equipment ready and make contact with your local schools, churches, scout groups, etc., and enjoy.

Expedition 12 Activity on the ISS

The Expedition 12 crew—made up of Bill McArthur, KC5ACR, Commander, and Flight Engineer Valery Tokarev—has been very active on the International Space Station. School contacts are now being scheduled for two a week and general operations have been greatly increased. The school contact backlog is now being reduced. Recently, the crossband repeater has also been active. This crew will do assembly and deployment of SuitSat. Finally, Bill has stated goals of WAC (Worked All Counties), WAS (Worked All States), and DXCC while on this mission, and good progress is being made on all of these goals.

Summary

SSETI Express, along with its passengers, was launched and has been declared a success in spite of difficulties. AMSAT BoD and Project EAGLE meetings defined the future of amateur radio satellites. Get ready to fully take advantage of SuitSat and help Bill, KC5ACR, work WAC, WAS, and DXCC from the ISS. Start planning now to attend the 2006 AMSAT Space Symposium in the San Francisco Bay area in 2006. Finally, support Phase IIIE and Project EAGLE with your available resources!

73, Keith, W5IU

By Tomas Hood,* NW7US/AAA0WA

PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

What's There To Do in the World of VHF Propagation?

In the last edition of this column, we took a look at dying sunspot Cycle 23 and how we're expecting its end by 2007. With the approach of end of the cycle, is there anything (propagationally speaking) worth exploring on the VHF and UHF bands?

Because of the nature of the Earth's orbit around our sun, we have two seasons each year when any adverse space weather has a greater influence on causing geomagnetic disturbances. The first is known as the Spring Equinoctial Season, and the second is known as the Autumnal Equinoctial Season (see figure 1). These are the two times during the course of the Earth's orbit around the sun when the Earth is in just the right position to be most influenced by solar activity.

The Spring Equinoctial Season peaks between March and April of each year. Is it likely during this final year of the current Cycle 23 that we will have significant geomagnetic disturbances to trigger the sort of auroral activity known to bring VHF activity?

The answer lies in exploring past solar cycles and knowing the nature of space weather during the decline and end of a sunspot cycle. Specifically, the answer is tied to the existence of coronal holes. Last quarter's column touched on the origin of the solar wind and the role coronal holes play in space weather.

One of the "atmospheric" layers around the sun is a region known as the corona. When a large area develops in the corona that is less dense than the surrounding area, a "coronal hole" opens up. These large-scale features are "open" magnetic-field regions that are sources of high-speed streams of solar electrons, protons, and ions (plasma).

Let's look at the relationship between coronal material and magnetic fields. The corona is so hot that the gases in it lose some of their electrons in the powerful collisions between atoms. This plasma is a mixture of positively charged ions and negatively charged electrons. An example of plasma is neon light. Because plasmas are electrically conductive, they can steer, or be steered by, magnetic fields. If the plasma streams out away from the sun, through a coronal hole, it drags a piece of the sun's magnetic field with it. These loops of magnetic force are stretched and dragged into interplanetary space by the inertia of the expanding plasma and the solar wind. When these magnetic forces impact the Earth, they are either diverted by or combined with Earth's magnetic field.

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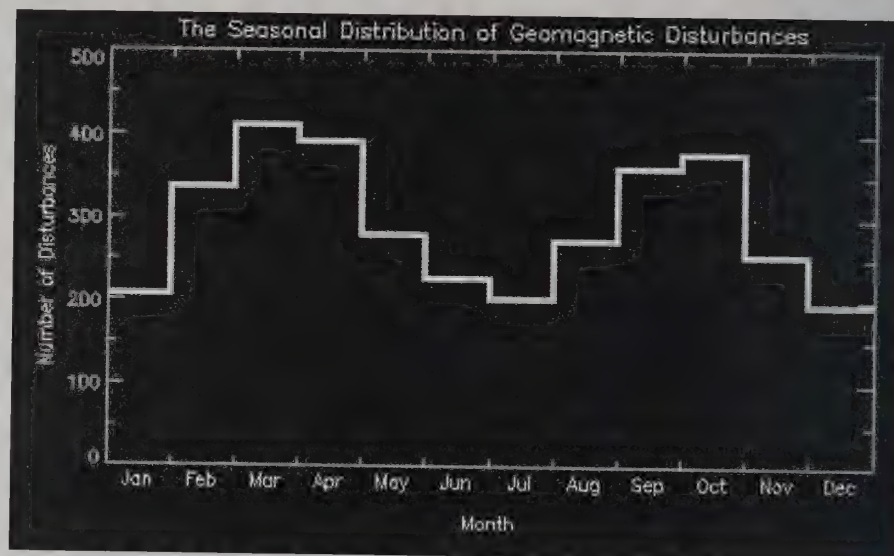

Figure 1. This graph by IPS, Australia shows the two seasonal geomagnetic peaks during the equinoctial periods (see text). (Source: IPS, Australia)

When the solar wind carries the coronal plasma past the Earth, geomagnetic storms may be triggered. The majority of geomagnetic disturbances are generated by the encounter with this passing plasma and magnetic-field flux. The ability to disturb the Earth's magnetosphere is a function of the solar wind speed, the strength of its magnetic field, and the presence of a strong southward magnetic-field component. Strong southward magnetic lines are most prevalent during the two yearly equinoxes.

The Earth's magnetosphere is formed from two essential ingredients—the Earth's magnetic field (which has much the same form as that of a bar magnet and is from pole-to-pole) and the solar wind. When the solar-wind magnetic-field lines combine with the Earth's magnetic field, the shape and intensity of this shield around the Earth are altered. The ionosphere is affected by these changes, either by an increase of ionization, or a decrease or even a depletion of ionization. Depressions in ionospheric density cause major communications problems, because radio frequencies that previously had been refracting off the ionosphere now punch through. The MUF (maximum usable frequency) can be decreased by a factor of two during an ionospheric storm event. Storm effects are more pronounced at high latitudes. When solar-wind magnetic-flux lines are oriented in a southerly

direction, aurora is possible. Propagation off aurora is an exciting activity.

What is the Aurora?

Aurora is a direct result of solar plasma interacting with gasses in the upper atmosphere. It is common to see aurora during active to severe geomagnetic storms. The magnetosphere is filled with electrons and protons that normally are trapped by lines of magnetic force that prevent them from escaping to space or descending to the planet below. The influence of solar wind that has been enhanced by coronal holes can cause some of those trapped particles to break loose, causing them to rain down on the atmosphere. Gasses in the atmosphere start to glow under the impact of these particles.

Different gasses give out various colors. Think of a neon sign and how the plasma inside the glass tube, when excited, glows with a bright color. These precipitating particles mostly follow the magnetic-field lines that run from Earth's magnetic poles and are concentrated in circular regions around the magnetic poles called "auroral ovals." These bands expand away from the poles during magnetic storms. The stronger the storm, the greater these ovals will expand. Sometimes they grow so large that people at middle latitudes, such as in California, can see these "Northern Lights."

In the early 1970s scientists recognized a connection between the component of the IMF (interplanetary magnetic field) that lies along Earth's magnetic axis (known as "B sub z" [B_z]) and Earth's changing seasons: The average size of B_z is greatest each year in early spring and autumn. So why do these storms increase in strength and number during spring and autumn?

As the sun rotates (one full rotation occurs about every 27 days), the plasma spewing out from the sun forms into a spiral shape known as the "Parker Spiral" (named after the scientist who first described it). This solar wind carries with it an interplanetary magnetic field, which ever expands away from the sun in this spiral. Think of one of those rotating lawn sprinklers with jets of water shooting away from the center; you can see a bending or curving of the water lines. As the Earth moves around the sun, these spiraling solar winds sweep into Earth's magnetosphere. How the magnetic field lines (IMF) in the solar wind interact with the magnetic-field lines of the magnetosphere is the key to geomagnetic storms and aurora.

At the magnetopause, the part of our planet's magnetosphere that fends off the solar wind, Earth's magnetic field points north. If the IMF tilts south (i.e., B_z becomes large and negative), it can partially cancel Earth's magnetic field at the point of contact. This causes the two magnetic fields (Earth's and the IMF) to link (think of how two magnets link with one magnet's south pole connecting with the other's north pole), creating a magnetic-field line from Earth directly into the solar wind. A south-pointing B_z opens a window, through which plasma from the solar wind and CME (coronal mass ejection) can reach Earth's inner magnetosphere, bombarding the gasses of the upper atmosphere.

Earth's magnetic dipole axis is most closely aligned with the Parker spiral in April and October. As a result, southward (and northward) excursions of B_z are greatest then. This is why aurora is most likely and strongest during the equinoctial months. When you see the solar-wind speed increase to over 500 kilometers per second, and the B_z remains mostly negative (the IMF is oriented mostly southward), expect an increase in geomagnetic activity, as revealed by the planetary *K*-index (*Kp*).

During this last year of Cycle 23, the spring equinoctial season will likely be mostly quiet, with few geomagnetic storms. If we do experience moderate to storm-level activity due to recurring coronal holes, look for aurora-mode propagation when the *Kp* rises above 4, and look for visual aurora after dark when the *Kp* rises above 5. The higher the *Kp*, the more likely you may see the visual lights. However, you don't have to see them to hear their influence on propagation. Listen for stations from over the poles that sound raspy or fluttery. Look for VHF DX. Sometimes it will enhance a path at certain frequencies, while other times it will degrade the signals. Sometimes signals will fade quickly, and then come back with great strength. The reason for this is that the radio signal is being refracted off the more highly ionized areas that are lit up. These ionized areas ebb and flow, so the ability to refract changes, and sometimes quickly. I've observed the effect of aurora and associated geomagnetic storminess even on lower HF frequencies.

Radio Aurora

If there are enough solar particles flowing down the Earth's magnetic-field lines and colliding with atmospheric atoms and molecules, ionization occurs. This ionization may be sufficient enough to reflect VHF and lower UHF radio waves, generally between 25 and 500 MHz. This usually occurs in conjunction with visual aurora, but the mechanism is a bit different, and it is possible to have one (visual or radio) without the other.

Using radio aurora, the chances of contacting stations over greater distances than would ordinarily be possible on the VHF frequencies is increased. Like its visual counterpart, radio aurora is very unpredictable. The thrill of the chase draws many VHF weak-signal DXers to working auroral DX.

VHF auroral echoes, or reflections, are most effective when the angle of incidence of the signal from the transmitter, with the geomagnetic field line, equals the angle of reflection from the field line to the receiver. Radio aurora is observed almost exclusively in a sector centered on magnetic north. The strength of signals reflected from the aurora is dependent on the wavelength when equivalent power levels are employed. Six-meter reflections can be expected to be much stronger than 2-meter reflections for the same transmitter output power. The polarization of the reflected signals is nearly the same as that of the transmitted signal.

The *K*-index is a good indicator of the expansion of the auroral oval, and the possible intensity of the aurora. When the *K*-index is higher than 5, most operators in the northern states and in Canada can expect favorable aurora conditions. If the *K*-index reaches 8 or 9, it is highly possible for radio aurora to be worked by stations as far south as California and Florida. Your magnetic latitude can be found using the map at <http://www.sec.noaa.gov/Aurora/globeNW.html>.

It is possible even during this last year of the cycle, because coronal holes continue to occur, that some life is left for seasonal exotic VHF activity via the aurora. It is not likely that we will see major geomagnetic storms during the yearly spring aurora season. However, with even moderate geomagnetic activity triggered by recurring coronal holes, we could be in for a surprise ot two if auroral activity occurs.

Meteors

While there are no major meteor showers during February and March, April has one major shower, the *Lyrids,* which will peak on April 22 at 1630 UTC. While this shower peaks at about 18 meteors per

hour, or about one every five minutes on average, radio bursts occur more often. This year we might see the meteor rate reach as high as 90 per hour.

The debris expelled by comet Thatcher as it moves through its orbit causes the *Lyrids*. It is a long-period comet that visits the inner solar system every 415 years or so. Despite this long period, there is activity every year at this time, so it is theorized that the comet must have been visiting the solar system for quite a long time. Over this long period, the debris left with each pass into the inner solar system has been pretty evenly distributed along the path of its orbit.

This material isn't quite evenly distributed, however, as there have been some years with outbursts of higher than usual meteor activity. The most recent of these outbursts occurred in 1982, with others occurring in 1803, 1922, and 1945. These outbursts are unpredictable and one could even occur this year. The best time to work this shower should be from midnight to early morning.

The Solar Cycle Pulse

The observed sunspot numbers from September through November 2005 are 22.1, 8.5, and 18.0. The smoothed sunspot counts for March through May 2005 are 33.6, 31.7, and 29.0.

The monthly 10.7-cm (preliminary) numbers from September through November 2005 are 90.8, 76.7, and 86.3. The smoothed 10.7-cm radio flux numbers for March through May 2005 are 97.2, 95.5, and 93.2.

The smoothed monthly sunspot numbers forecast for February through April 2006 are 11.4, 9.5, and 8.8, while the smoothed monthly 10.7 cm is predicted to be 75.5, 73.8, and 72.7 for the same period. Give or take about 15 points for all predictions.

The smoothed planetary *A*-index (*Ap*) numbers from March through May 2005 are 15.3, 15.7, and14.8. This is just about the same number as the year before. The monthly readings from September through November 2005 are 21, 7, and 8. These are significantly more quiet than last year.

(Note that these are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review).

Space Weather Week

Every year the National Oceanic & Atmospheric Administration (NOAA), the Air Force Research Laboratory, the NSF Division of Atmospheric Science, and the NASA Earth-Sun System Division co-sponsor the Space Environment Center Space Weather Week <http://www.sec.noaa.gov/sww/index.html>. This year it will be held from April 25–28 at the Boulder, Colorado Millennium Hotel. The topics are always pretty hot! The 2005 conference included topics such as "Space Weather Cycles and their Impact," "The Ionosphere and its Impact on Communications and Navigation," "SEC and Space Weather Products," "The Year in Review—Space Weather Storms of 2004 and early 2005," "Solar Wind Forecasting," and many more. This year promises more of the same cutting-edge reporting on current research, discoveries, modeling, and perhaps even details on Cycle 23's ending and highlights. The registration fee is not too high, so if you are in the area, you might want to check it out. I am not yet sure if I will be able to attend, although I hope to. If I do, I'll report on the highlights next time.

Feedback, Comments, Observations Solicited!

I am looking forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail, or drop me a letter about your VHF/UHF experiences (sporadic-*E,* meteor scatter?). I'll create summaries and share them with the readership. I look forward to hearing from you. You are welcome to also share your reports at my public forums at <http://hfradio.org/forums/>. Up-to-date propagation information is found at my propagation center, at <http://prop.hfradio.org/> and via cell phone at <http://wap.hfradio.org/>.

Until the next issue, happy weak-signal DXing.

73, Tomas, NW7US

CQ's 6 Meter and Satellite WAZ Awards

(As of January 1, 2006)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones needed to have all 40 confirmed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23.24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	2,16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25,28,30,31,32
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	1,10,18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,10,12,18,19,23,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	KØSQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IKØPEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28
72	K4MQG	17,18,19,21,22,23,24,25,26,28,29,30,34,39
73	JF6EZY	2,4,5,6,9,19,34,35,36,40
74	VE1YX	17,18,19,23,24,26,28,29,30,34
75	OK1VBN	1,2,3,6,7,10,12,18,19,22,23,24,32,34
76	UT7QF	1,2,3,6,10,12,13,19,24,26,30,31

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. In 2001 we "lowered the bar" from the original 40 zone requirement to encourage participation in this very difficult award. A Satellite WAZ certificate will indicate the number of zones that are confirmed when the applicant first applies for the award.

Endorsement stickers are not offered for this award. However, an embossed, gold seal will be issued to you when you finally confirm that last zone.

Rules and applications for the WAZ program may be obtained by sending a large SAE with two units of postage or an address label and $1.00 to the WAZ Award Manager: Floyd Gerald, N5FG, 17 Green Hollow Rd., Wiggins, MS 39577. The processing fee for all CQ awards is $6.00 for subscribers (please include your most recent *CQ* or *CQ VHF* mailing label or a copy) and $12.00 for nonsubscribers. Please make all checks payable to Floyd Gerald. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. N5FG may also be reached via e-mail: <n5fg@cq-amateur-radio.com>.

17 Green Hollow Rd., Wiggins, MS 39577; e-mail: <n5fg@cq-amateur-radio.com>

By Del Schier,* K1UHF

AIRBORNE RADIO

Using Amateur Radio to Control Model Aircraft

Getting Started

For your first model-aircraft flight you need to choose the right equipment and do some homework. This time I will help you pick your first airplane, and in the next few installments of this column I will talk about radios, motors, props, setting up an airplane, and learning to fly.

Sometimes people get their ham license, buy an HT, get on the local repeater, and then quickly become bored. They give up the hobby before they really figure out what amateur radio is about, and go back to surfing the web. You also can easily get turned off by an RC (radio-controlled) model. Some people go out and purchase a poor, ready-to-fly model airplane from a toy store instead of an RC shop. Their first flight is in their back yard with 20-mph winds. Their involvement with RC lasts about three seconds—the duration of the flight. Hopefully, I will not be giving you a "crash" course in RC!

My first RC model was a sailplane called a Gentle Lady. It was a $17 kit glider with a 2-meter wingspan. The Gentle Lady was a very good first choice. I learned with it and flew it for years. Twenty-plus years later, I gave it away so someone else could get started in the hobby. It may still be flying today.

RC airplanes can give years of pleasure, but eventually they are bound to crash or somehow get lost. I personally have damaged more models in transporting them than flying them, but that's not to say I haven't had a few bad landings and other mishaps. With RC, like ham radio, there is always a challenge. Both involve building or setting up, and operating (flying).

You will find that many airplanes are dubbed "trainers," "easy to fly," "perfect for beginners," or some such term. You will find that you get a different opinion from each seasoned modeler with whom you talk, the same as with ham equipment. I will tell you what I think you need to learn and consider before you purchase your first plane.

A beginner airplane needs to be docile. By docile I mean that it should have controls that are not very sensitive and it should like to fly straight and level. To achieve this, it helps to have a top-mounted wing, called a *high-wing* or *parasol* wing. A wing on top gives pendulum stability, just like it sounds.

Another thing to look for is a fair amount of *dihedral*. Dihedral is the V bend in the center of the wing that causes an airplane to roll back to level flight with no control input. Airplanes are controlled in three axes: yaw (left right), pitch (up and down), and roll (rotation around the fuselage center line).

For stability, the tail feathers—the horizontal and vertical stabilizers—should be rather large in relation to the wing and mounted farther aft than normal. This damps and stabilizes the yaw and pitch movements and causes an airplane to fly straight and level. The control surfaces should be relatively small and not have much travel, or the airplane will be overly sensitive to your control inputs. A high-performance aerobatic airplane is pretty much the opposite.

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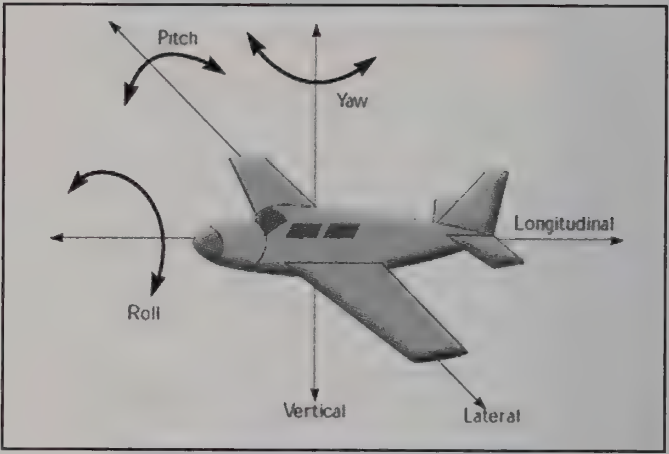
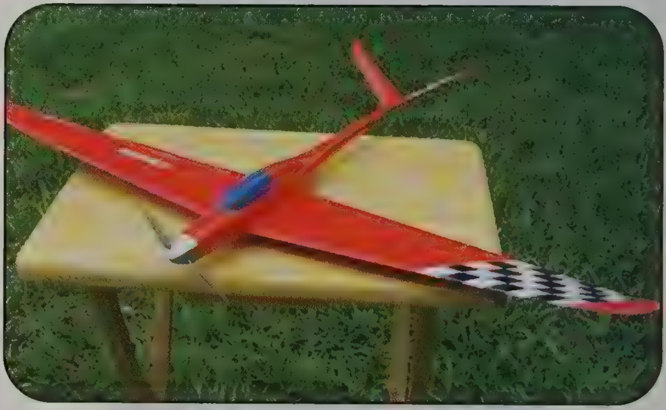


Figure 1. Yaw, pitch, and roll.

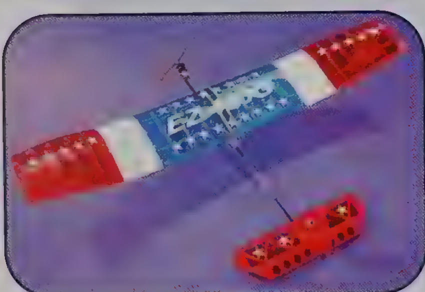


This is Not what you want—a 150-mph pylon racer!

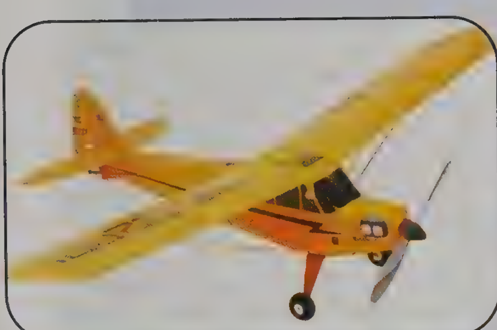
The CG, center of gravity, should be set a bit forward. A forward CG causes a stronger balance between the horizontal stabilizer's down force and the forward weight. That's right: the tail (horizontal stabilizer) pushes the airplane down. A forward CG causes the plane to pitch up after dive and the opposite after being nose up. Too much of good thing, however, can make an airplane so stable that it cannot maneuver quickly enough to avoid an obstacle.

Perhaps the most important thing about a trainer is that it flies slowly. Flying speed is a direct function of wing loading. Wing loading is simply how large the wing is in relation to the airplane's weight and is usually expressed in oz/sq ft. Any airplane under about 7 oz/sq ft. is considered lightly loaded and will fly slowly. A slow-flying airplane is best for a beginner, as it gives you more time to think about things and stay out of trouble. The radius of a turn is directly proportional to flying speed, so a slow-flying plane can make smaller diam-

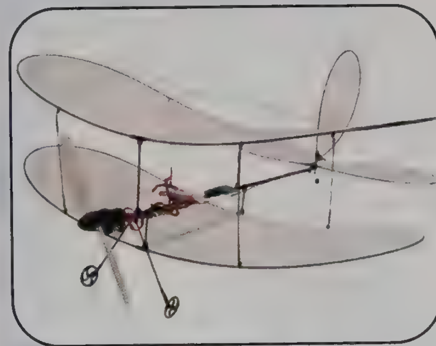
The Easy Star, a good foam trainer. Notice the prop out of harm's way.



The simple, slow, and good-flying EZ 400G, which is great with brushless power.



A ready to fly, which means it comes complete with radio, but not on 6 meters. The little landing gear may cause it to tip over in grass.



This plane flies very slowly and is very strong for its weight, but it is best for flying indoors without any wind.

The simple, rugged, and inexpensive Slow Stick from GWS. Notice the aluminum-tube fuselage.

The rugged, simple, and easy-to-build SkyGo is made of foam.

eter turns. A down side of light wing loading is that the airplane will be more susceptible to air turbulence and will need to be flown in calm conditions.

There are considerations that may be more up to the individual, but there are certain things everyone should look for. An airplane that is simple in every way is good. Only three channels of control—rudder, elevator, and throttle—are what you need. Look for something easy to build or get an ARF (almost ready to fly) with a good set of instructions.

It should be obvious, but your first plane should be rugged. No airplane will survive a bad crash. If it were that strong, it wouldn't fly. We have a problem here! If it is supposed to be light, how can it be strong? Basically, that depends on how it is designed and what materials it is made from. You can get a clue by studying how the motor and landing-gear areas are built and also by looking at how the wing is attached.

Recently, foam airplanes have become popular, although foam is not always strong. One type of foam that is incredibly tough is EPP, expanded polypropylene. EPP is a foam that when bent or squashed springs back, but it is fairly stiff. You will see the use of carbon fiber to strengthen an airplane, but not usually in a trainer.

The battery is the single component that weighs the most, so in a crash consider what happens with the battery. It really helps to have a strong, light airplane by using a high power-to-weight lithium battery and brushless motor.

You may wish to start out with a glider as I did, but today with electric power it is easy to start out with a motor. You can get a nice-looking airplane with which to learn. It doesn't have to look like a trainer. Many airplanes can be used as trainers, provided they are rigged with forward CG and modest control authority. However, don't get carried away with a fancy-looking first airplane if all you want to do is learn to fly.

73, and happy flying! Del, K1UHF

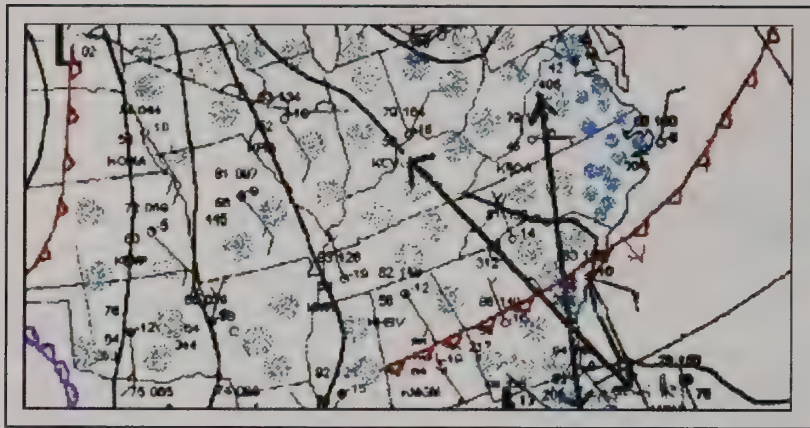


*Figure 3. Frontal activity in North America, with cold fronts. A warm front is also present here in the lower left-hand corner. This map was recorded on May 11, 1999, when a good opening was taking place between W1, 2, 3, and 8 into W4. It shows the front and the propagation called sporadic-*E *taking place over it.*

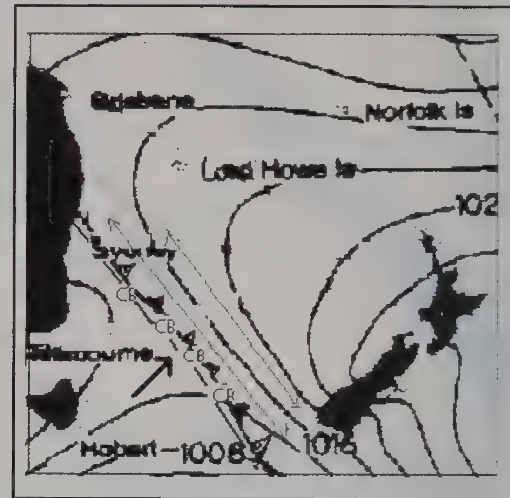


Figure 4. Here is a typical map for New Zealand showing the warm winds. The double-arrow lines are the lines of propagation.

stricted views for 360 degrees at a height of 20 meters above ground, and on top of a 100 meter hill the receiving position was perfect.

It did not take long to establish that a series of weather patterns was evolving. Every time the same weather pattern occurred, contacts with the same place occurred. Things such as air pressure were recorded, as were air temperatures, and again a regular pattern was also shown to exist. I also noted there were several regular weather patterns, and if they were in the line of propagation, no contacts were ever recorded!

From my years of recorded data, I had established that for 2 meters the following seven conditions, or modes, produced propagation. They also do it for 6 meters, but with less intense conditions required. In describing how propagation takes place, there are seasons for each mode! Even the areas where the propagation takes place change from year to year, and this is also predictable. Now for the simple part:

Mode 1: Anticyclones, with an air pressure of 1026 mb and an air temperature of around 28–30° C in the propagation path, produced propagation across the center of the anticyclone out to 2250 km (1100+ km each side of center) (and under very good conditions much farther). This is the shortest distance of interest to me. To achieve this, your antenna needs to be unobstructed and be able to receive signals coming in at or below 3 degrees for at least 10 to 15 km. It was accountable for about 80–90% of all 2-meter propagation in 2004–5!

Mode 2: Anticyclones, with an air pressure of 1032+ mb and an air temperature of 26°+ C, bring much higher angles of propagation, over 8 to 10 degrees. However, they only account for about 2–5% of the propagation.

Figure 2 is my anticyclone chart, which shows how to predict when the anticyclones will produce propagation. Drawing a line between the two basic components, the lowest air temperature along the path and air pressure between you and your intended destination, crossing the center line it must be equal to or above point 8 or 10 on the chart for 2 meters. For 70 cm, look at point 11 on the 2-meter scale. A closer look will show that as one side goes up, the other side comes down. However, there is a point at which things become too low for any propagation. The left-hand chart is for 6 meters, while the other one is for 2 meters and 70 cm. Modes 1 and 2 accounted for approximately 90% of the 2-meter propagation. It is easy to obtain these details from your newspaper's weather map.

Mode 3: Frontal activity associated with warm or cold fronts (see mode 4).

Mode 4: Lightning flashes from thunderstorms, traveling at the leading edge of cold fronts as in figure 3, increase the ionization of the *E*-layer and bring about the propagation that has been called sporadic-*E*, giving us those incredible strong signals we like to hear. One cold front is shown over the eastern side of North America and another on the western side. While moving in an easterly direction, they are also advancing towards the equator. These produce north/south propagation on 2 and 6 meters over the main area of the lightning. While I see it in Australia, North America and Europe, the north/south path does not happen in New Zealand on 2 meters, as the available path length here is too short.

On 6 meters signals reach S9+ 20 dB between Auckland and Christchurch. Excellent propagation occurs here in the east/west paths when the front is lying in a north/south direction in the central Tasman Sea. Propagation percentage on 2 meters may vary from 1% to 5%, while on 6 meters to 35%. Side scatter and most backscatter are by-products of lightning storms. Long warm fronts also contain lightning as they come into contact with cold conditions and can provide spectacular propagation, including on 2 meters.

Mode 5: Ducts traveling in the warm winds ahead of a cold front in the southern Tasman Sea are shown by double-arrow lines in figure 4. Signals can be extremely strong, to the point where we refer to these as pipelines to VK2 from Christchurch. For the Northern Hemisphere they are in the warm southwest winds and can be confused with jet-stream winds.

Mode 6: Ducts traveling in jet-stream winds at a height of 10 km. The spring is the best time of year for these, although they can come during the winter, as the one shown in figure 5. Some years the northern jet-stream winds do not come as far south as us. They are narrow and provide very strong propagation.

Figure 5 was recorded on August 14, 1996, and it shows the duct in the color mauve at a height of 10 km. This gave propagation from Auckland to Brisbane on 6 meters, when it became centered over both cities. The map was by weather fax, and it shows two cloud banks at the leading edge of two cold fronts. During spring, very strong jet-stream winds can occur between 20 degrees south (or north) and 45 degrees south (or north). These have produced incredible openings as high as 1296 MHz here, with extremely strong signals. I have seen them last up to three days, and even handheld transceivers have been able to work over 2250 km! If you have access to this information, you can see them coming for several days. They are very narrow and cannot be accessed from outside the width of the duct.

Figure 5. A duct in a jet-wind stream north of Tasmania.

In New Zealand we have two lines of jet-stream winds, one over northern Australia and the other over southern Australia. I have recorded ducts over 2500 km long coming from Australia to all over New Zealand. My map is from weather fax, but ducts can be seen in newspaper maps by the long, straight cloud formations with very sharply defined edges of cloud on one side, usually on the cold side.

Mode 7, AU: Whether it is AU or AU sporadic-*E*, these should be well understood and need no further comment here.

The mode 1 anticyclones have been known and well accepted for many years. Here I can only make contacts with Australia by mode 2, as I have a 10-degree hill obstruction. The ZL3s in Christchurch can only make contact with VKs on 2 meters when mode 2 is current or when mode 4 is active. They have a mountain range to cross at an average height of 2000 meters and 75 km in front of them.

I have not shown an occluded front. However, when an occluded front is in the line of propagation, I have never seen any propagation take place! You will also see many weak anticyclones—1008 mb to 1018 mb. These are also far too weak and do nothing, so again *no* propagation has ever been recorded under these conditions. We must have very strong action in our weather patterns, high pressure or big differences from the warm to cold side of cold fronts, as these are what bring about real action.

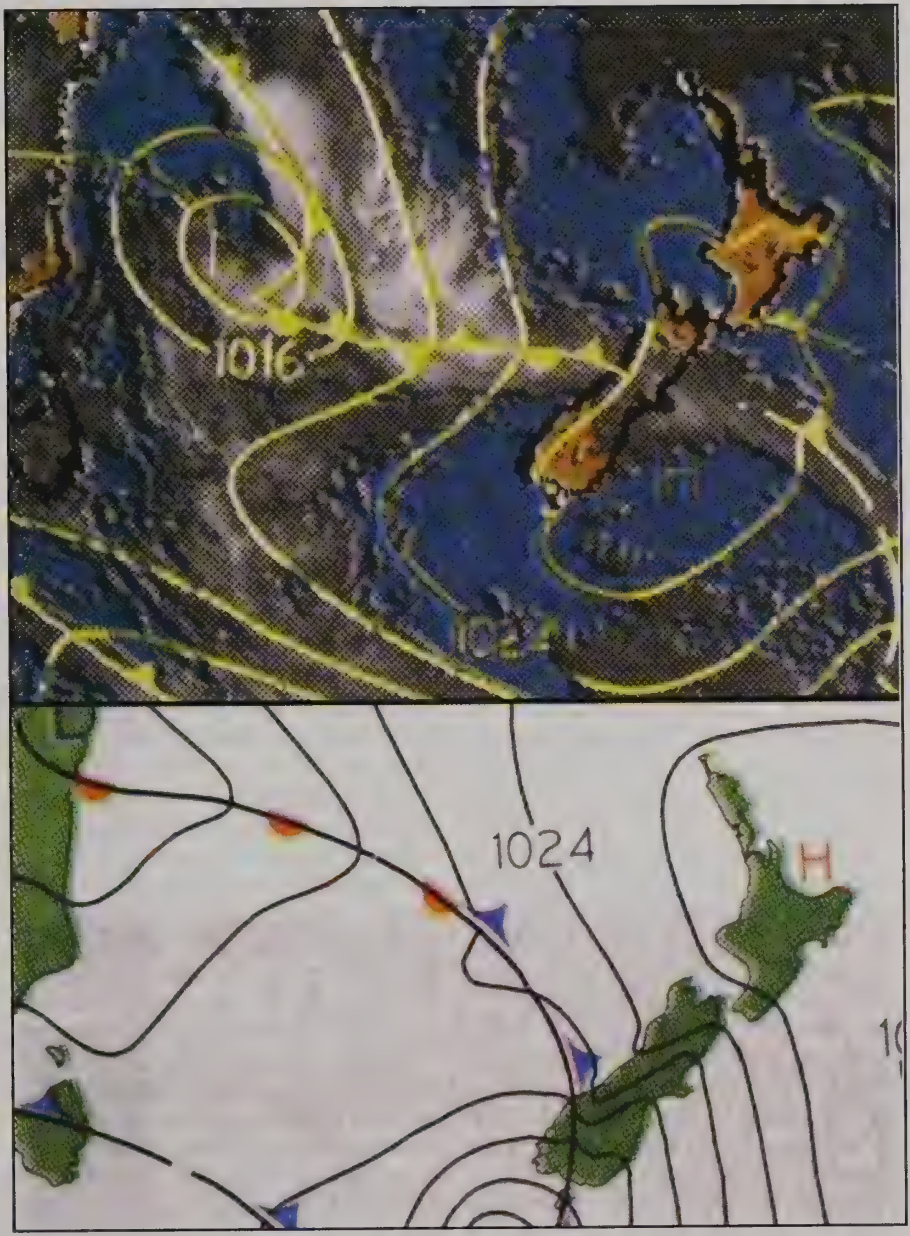


Figure 6. A satellite picture taken on Saturday, September 3, 2005 at the end of winter in New Zealand, along with a sea-level isobar map taken 18 hours later on Sunday, September 4.

I think many amateurs understand aurora—how it comes about and how the received signals are returned to us, with

Northern Hemisphere* 6 Meter Calendar

January	February	March	April	May	June	July	August	September	October	November	December
E	ACE, weak	from 21st	D	D	ABCDE	AB	A	A, weak	from 21st	AE, weak	AE, weak

Northern Hemisphere* 2 Meter Calendar

January	February	March	April	May	June	July	August	September	October	November	December
—	—	from 21st	D	D	ABCDE	AB	A	A, weak	A, very weak	—	—

Legend: A = low-angle anticyclones; B = high-angle anticyclones; C = lightning; D = ducts with jet winds; E = ducts in warm winds ahead of cold or warm fronts.

**For the Southern Hemisphere change January to July. The mode C can occur at any time of the year, but peaks as shown in the list.*

Table 1. Weather conditions to produce propagation.

all the sound distorted, by the distinctive AU buzz. I also take it that many amateurs understand how this area about 70 km high ionizes the *E*-layer and produces both single-hop and double-hop sporadic-*E*. This propagation has been accepted for many years.

Lightning and Thunderstorms

Now let us think about lightning, where we have a very large series of exceptionally strong lightning flashes (a recent storm here produced over 5000 strikes in a small area in a few hours!). From them large sprites develop (examples have been photographed by NASA) which look like large carrot-shaped flashes going up to 70 km in height.

It could be said that sprites are very much like aurora, but fed with energy from nearer ground instead of by radiation from the sun. They are different in their origin, but have the same effect, as they also ionize the *E*-layer and produce what we have called sporadic-*E* for many years. Let me now produce some recorded evidence.

Figure 6 shows a satellite picture taken on Saturday, September 3, 2005, at the end of winter in New Zealand, along with the sea level isobar map taken 18 hours later on Sunday, September 4. The thunderstorm in the cold front gave propagation from Christchurch, ZL3, to VK2, Australia. You can also see how the depression had moved considerably to the southeast overnight, taking the active area of the cold front with it. Winter propagation from the lightning storm as it came in from the Tasman Sea took place while the storm was centered between ZL3 and VK2.

As I prepared to start my study, I wondered just whom to contact for more assistance. The first place I contacted was our local TV weather department, and I put my case to them. Could they give a brief comment each night saying if there were any thunderstorms within 1500 km of Auckland, where they were located, and what the activity was—weak or very strong, etc. After several discussions, they agreed to do this, and I am pleased to say that ten years later they are still doing it every night. In this way I know exactly where these storms are and what fronts,etc., are involved in them.

If you cannot get this information from a source such as that, you will have to use your newspaper maps (see figure 7). First look at the map showing the isobars and see where the fronts, if any, are located. Next look at the satellite map showing the cloud formation. You will notice different depths of color (or gray scale). Near the center of the cloud, look for a small section that is nearly white; this is where thunderstorms are active, as it is the highest point in the clouds. You now have the place to ward which to beam your antenna.

In judging where to point your beam, remember that most of these storms are traveling at an average speed of 25 knots, so allow for the deviation in your beam heading. By this means you can now find the storm and follow it as it travels, even days before it comes between you and any amateur stations, until it places itself in the center of the propagation path you are looking for. Each day have a look at the weather maps, as that is where the information can be gained very quickly. In New Zealand we seldom have more than one weather pattern active, but in big continental areas such North America, Europe, and even Australia, several weather patterns can and do actively provide propagation at the same time in different directions.

Here are some other examples:

May 22, 1999: I was looking at the North American weather map that showed where thunder/lightning storms of high intensity were located. Above the location of the Millstone Digisonde station there was a sign of good activity. This looked interesting, so I looked at the dxworld.com 6-meter page, and here we had contacts taking place from Canada to the United States directly over the lightning storm as shown on the map.

Armed with this information, I connected to the Millstone web page and looked up the time list and downloaded the charts. There it was showing up very nicely. The chart showed that the *E*-layer had reached 12.5 MHz. Taking the usual multiplication factor of 5, we now had propagation recorded for 6 meters. This was a confirmed mode of propagation lightning (otherwise known as sporadic-*E*), because we had the weather map showing the lightning storm, the contacts, and the ionsonde charts showing ionization to 12.5 MHz all at the same time. When the storm died out, the ionsonde data returned to normal and propagation ceased.

December 21, 1995 at 6 PM: From 5 PM to 6 PM I had a poor opening on 6 meters to Sydney. At two minutes past 6 PM the band suddenly opened with Sydney stations S9+. Then I found I had VK6 stations S7 (Western Australia, 5500 km). After exchanging reports with these stations I switched to 2 meters, and yes, the Sydney stations were S9 on 2 meters.

Just before 7 PM I listened to the TV weather for my lightning update. What did they say? A very aggressive thunderstorm started at two minutes past 6, and it was located in the center of the path between Auckland and Sydney. That was exactly the same time when both bands opened here! Local stations farther north

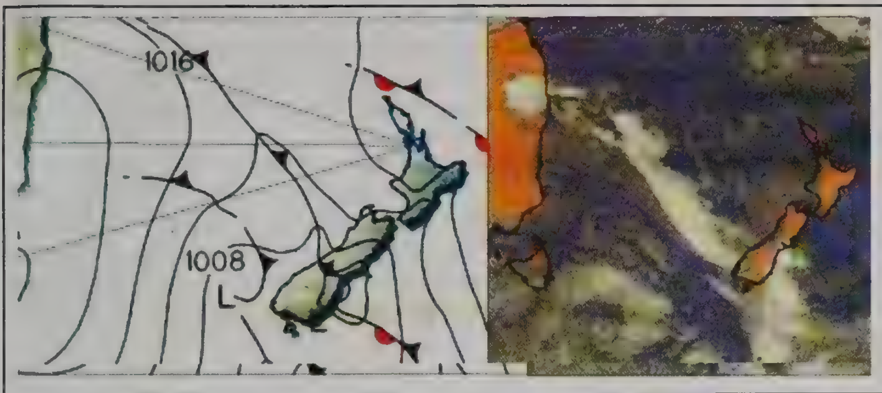


Figure 7. The isobar map and satellite picture were taken on December 27 and December 28, 2004, respectively.

or south of Auckland did not get the propagation we had, as their path was out of the area ionized by the thunderstorm. The next day the newspapers commented that the storm had died out at around 8 PM, and that was the time when 2 meters closed to Sydney. This type of information is a do-it-yourself job. You have to organize these things yourself, as they are not available off the shelf.

Some time back I heard VK9NS in Norfolk Island some 1200 km north of me calling ZL4TBN. Here I had perfect copy of VK9NS by backscatter with a lightning storm centered between me and the ZL4. I called VK9NS and we exchanged reports; I could not hear him on the direct path. This is a perfect example of backscatter, with signals being reflected off the ionization brought about by the lightning flashes. As I have said, we get a lot of propagation like this, as cold fronts sweep up the south island from the south, and these usually have lightning storms in the leading edge of the cold front.

Halfway between Christchurch and Auckland is an area that grows a lot of apples. When they get hail from thunderstorms, we get the report as to how many thousands of cases of apples, etc., were destroyed. Every time we get these reports, I find I have been in contact with amateurs in Christchurch! Again, confirmation of lightning producing propagation.

Here is another good example of backscatter, etc.: The TV weather mentioned that there was a lightning storm traveling south in the northern section of the sea between us and VK4 so I watched for it, and sure enough the VK4 beacon came in, so I telephoned Trevor, VK4AFL, as we did on many occasions during my study, and had a couple of words; can we report on 6 meters? The band was open for the short time as the storm moved south, another lightning opening? While this was happening, another local station (75 km away) from me, was hearing the contact on backscatter although he could not hear the VK4.

I have many openings just like these recorded. In addition, another very interesting opening covering 2 meters took place in December 2004 starting around the 20th. A small depression developed in the North Tasman Sea and moved slowly south. It was fed by two streams of warm moist air. One came from the Coral Sea area, while the other came from east of Fiji. They joined together and fed into the depression as it moved south. By the time it was nearer to the west of us, the frontal sector was around 2500 km long, and in the southern 1000 km there was lightning activity getting stronger as the depression deepened.

Around December 23, it was due west of us and 6 meters was extremely good, with small openings on 2 meters to VK2 and VK4. By December 25, it was west of Christchurch and located in the center of the path between Christchurch and Tasmania. The storm peaked at around 5 PM when the 2-meter band suddenly opened to Tasmania from Christchurch (about 2250 km). Many contacts resulted during the two-hour opening, including ones on SSB, FM repeater, and even with handhelds. It was classic, even though these openings are relatively rare on 2 meters. Patience is very much needed.

While we are on the subject of lightning, the two weather pictures shown in figure 7 relate to a cold front advancing northeast. It produced 6-meter openings on December 27 and 28. The right-hand side shows the satellite map of the cloud formation. On December 27, 6 meters was open all day, and on December 28, 2 meters opened to VK2 and VK4 as well. When the cold front swept over Christchurch around midday on December 28, we had the usual opening from Auckland to Christchurch, another classic example. The weather patterns we have been using are MSL maps (mean sea level).

There can also be times when two different weather patterns are operating at the same time at different altitudes! The TV people brought this to my attention when discussing jet streams, as they showed me a jet stream that had a lot of thunderstorms traveling with it, starting at 10 km high! It was traveling east just north of New Caledonia, and as it happened, a number of VK4s had great propagation to eastern W-land by the lightning storms ionizing the *E*-layer. It only lasted the one day, but all I can say is be aware of this condition. I have missed fronts just the same by not checking higher. If you are very keen, check the upper levels. However, for most of us the MSL maps are fine.

There is one thing I would like, and that is a meter of some kind that would measure the intensity of the lightning ionizing the *E*-layer. We could then gauge when the intensity is strong enough to get propagation.

I think we have discussed lightning enough here. I have given the details so others can try it out and written where to search for the information. You can watch these modes coming in for about a week or even longer!

Anticyclones

Now let's look at anticyclones. The most common ones, around 1024 mb, are very well known. There have been excellent descriptions of how they produce propagation in many publications. Thus, I won't repeat old information, other than to say that propagation takes place at a height of around 2 km. This makes living next to hill hills difficult for propagation to get in or out!

We do have another group of anticyclones that become very intense, reaching 1036 to 1040 mb. These are the ones of interest to me, as they produce propagation from higher angles-10 degrees or maybe higher. It is only when these happen that I can work VK on 2 meters; the same applies for stations in Christchurch. They do work VK, but only with very high readings of air pressure.

This type of anticyclone can come in winter, but the air temperatures are much too cold to produce propagation. Therefore, the best time to look for them is in July in the Northern Hemisphere or in January in the Southern Hemisphere. They can also extend into the next month. I have included my chart showing how air temperatures and air pressures work in conjunction to produce propagation. Read your weather map and get the lowest temperature along the path. However, you need the anticyclone to at least be at the prescribed level of mb, near both ends of the path, and watch out that the air temperature does not go low along the path.

If I find there is a possibility of propagation taking place I look for beacons on 10 meters! Now I know that 15 meters will open on tropo modes before 10 meters does. However, 15 has too many other modes of propagation, so I only use 10 meter beacons. When they appear I look for 6-meter beacons. From there I keep checking 2 meters for any beacons, although I find the 2-meter stations come through just as well, if not better.

Predicting Propagation

When dealing with VHF and UHF, each spring we start a new season, so the first contacts for the Northern Hemisphere begin on March 21 and take place around 20 degrees latitude. This is the time when the sun starts to move back into the Northern Hemisphere, or as the days start to become longer.

We need to realize that propagation comes to us *as the sun brings very active weather and warmer temperatures* into our region. Here we find that the first propagation takes place between New Caledonia and Northern Australia, usually by early October. By October 22 (May in Northern Hemisphere), the first 2-meter contacts between Auckland and VK4 (Northern Australia) could take place. By November 22, possible propagation has come down toVK2 +VK4 into New Zealand, or around 40 degrees south. I would imagine the same latitude applies for the Northern Hemisphere as well.

By December 20, propagation is at the peak, and it will stay like that for about 10–14 days, after which things will change. It is not until after December 20 that we hear VK3 or VK7 on 2 meters, as they are the last areas to be heard. By mid-January here, or mid-July in the Northern Hemisphere, you have the sun moving out of your hemisphere, and all the nasty weather, frontal activity, lightning, and very unstable conditions, which produce excellent propagation, all start to move back towards the equatorial regions.

As the unstable weather departs, we are left with big, stable anticyclones—up to 1040 mb with calm weather—and these can give very extensive propagation, depending on the intensity of the anticyclone up to 1296 MHz. With these, propagation can be very wide, out to several thousand kilometers in each direction. The time for these is the middle of June to the end of August in the Northern Hemisphere (December to February in the Southern Hemisphere), and in the large continental area it is a bit longer. Look for the last of these anticyclones in late August (February in the Southern Hemisphere), as it is nearly all over, with the sun going to the other hemisphere.

For an example, look at figure 1. The quiet winter season arrives, and for 6 meters the intensity of the anticyclones will need to be nearer 1036–1040 mb, instead of the 1026 mb which gave propagation in the middle of the season. However, it is much harder to obtain temperatures that are high enough in winter to make 2 meters possible.

For propagation to take place by frontal activity in winter, we require a big temperature change from the warm side to the cold. Here it is usually accompanied by reports from our weather office of snow down to very low levels, such as sea level at 45 degrees! This is what has happened on July 15. A cold front with snow to low levels swept over the South Island, and yes, there was an opening to ZL3 on 6 meters from Auckland in the mid-afternoon; this was the first opening for winter. Anticyclones need to be very strong, such as 1040 mb.

I have seen years of nothing, and then I have also seen good years when propagation has lasted as long as a week in late August! The mode of propagation was a depression from north which drifted south with a long frontal section up to Fiji, some 3000 km long. However, there is no guarantee that you will get any propagation, and there have been times when we have gone three months without any propagation.

The early propagation here usually comes from very long ducts traveling under jet-wind streams. I have recorded them out to 5000 km long, from Darwin to over the Chatham Islands. Once you know what to look for, you can even get used to picking these by the smell of the moist, humid air! It is like listening on 6 or 2 meters with an old hand can pick—an open band just by the crystal sound of the noise.

Earlier I showed a short duct 2250 km long. It provided propagation up to and possibly above 1296 MHz. I have seen many last three days with excellent propagation on all bands up to 1296 MHz, but remember that if the signal is transmitted on vertical, that is how it comes out at the other end. I have seen a difference of up to seven S points between horizontal and vertical!

During December (or June in the Northern Hemisphere) all modes are available, so we can really get lots of propagation. At that time of the year look for connecting extensions, such as in December 2004, when we had triple hop, with two lightning storms and a large anticyclone producing propagation to 5500 km.

There are times during mid-summer when an anticyclone is the current producer of propagation. That propagation dies out between 8 and10 PM and then can suddenly re-occur at 2 AM. This comes about because when the sun goes down, the evening temperatures drop, and this can lead to the equating of temperature to air pressure becoming too low to produce propagation.

Because all weather patterns keep shifting at night, we could have the anticyclone shift to a denser section, giving several more mb of pressure and once again restoring propagation. If propagation was via a duct, it would proceed all night and still can be there in the morning. Cold fronts with lightning can come at any time of the day or night!

Here is the next conundrum: The areas where propagation takes place can vary from year to year. Why?

La-Niña, El-Niño, and Normal relate to the sea temperatures. La-Niña means warmer than usual sea temperatures. El-Niño means the sea is colder than usual. Normal is self explanatory. What does this have to do with propagation? A lot. Cold fronts come from the cold climates. As they move farther towards the equator, the sea temperatures are the biggest changers of temperature or killers of cold fronts.

If you are waiting for propagation from a cold front and the cold front meets warm sea temperatures, the cold front will die out and become an occluded front. Occluded fronts never produce any prop-

agation, as there is very little change in temperature from the warm side to the cold side of the front. The propagation you were looking for will never come! These weather conditions are very important, as for the last 50 years my records prove La-Niña produced very little propagation at 38 degrees south—in fact, only about one third the amount produced by El-Niño and Normal conditions.

Dr. Mullin of our NIWA has kindly supplied me with his list of the three weather types that were current over the last 50 years. The sea temperatures govern how near to the equator the cold fronts proceed, and somehow anticyclones follow a similar path before departing to the east. With La-Niña, frontal activity dies before it gets this far north; all the propagation with it is gone and the anticyclones pass to the south of us at 38 degrees south. If you contact your weather office around May (September in the Southern Hemisphere), you can usually get a prediction for the summer months. If it is going to be La-Niña, plan to paint the house or go on that extended holiday with the family. If it is Normal or El-Niño, get the antennas ready. With La-Niña, I only managed to work to the south of me with the usual number of contacts to that area but very little else.

When Normal is prevailing, the same front or anticyclones would come north to about 35 degrees and then turn to the east, passing nicely over us. Propagation is good for us, as most of our contacts take place here when there is no *F2* propagation. However, with El-Niño the fronts or anticyclones proceed north to around 25 degrees and then swing to the east. These are the ones we really want, as while they give propagation in all directions, it also allows us to use the tropo to make the *F2* areas and bring us our *F2* propagation. That shows you how much variation can occur from those three different patterns of weather! From these alone you can now see how a season can be so different from one year to another!

There is one thing to remember about predicting propagation on these frequencies: The weather that governs the places you contact is located 250 to 1500 km away from your location, so what is happening outside your window has very little effect on what you will work.

You will note that there are many subjects I have not covered in this article, as they require more space than is available. these include important ones such as TEP (transequatorial propagation) and *F2* on 6 meters. For example, to work France from ZL3 entails four tropo hops plus one *F2*! To do it proper justice, it will be covered at a later date. Knowing what to look for and when to look is the key to success on 6 and 2 meters and 70 cm.

All of my comments come from over 50 years of operating on these bands and data from my log books, as well as the four years of study I did in the mid to late 1990s. I am sure there will be variations in the next few years as more amateurs continue to study propagation. To any one else who undertakes this task, my best wishes. To the rest, use this information and enjoy our amateur bands. ■

Use of a mandrel was not necessary; simply squeezing the stubs on alternate sides in a 4-inch wide vise produced sufficiently round diameters to allow them to be pressed by hand into the element ends so that about an inch protrudes from the element. These "tuning stubs" can be withdrawn or inserted into the element ends as necessary to achieve a resonant length at the design frequency. When the beam has been adjusted to frequency, use a propane torch to flow a little solder around the element ends where the stubs protrude. Capillary action will draw the solder into the joint.

A 300-ohm ladder-line feeder was chosen rather the 450-ohm type, because it is more flexible and fits the standard TV standoff insulators and wall feed-though bushings. If 450-ohm line is used, the delta-match lengths will change slightly, but are easily determined by the tune-up method described above.

When the beam element lengths and delta match are adjusted so that the SWR indication on the coax is near 1:1 at the design frequency, the SWR on the ladder line will also be near 1:1. Solder the delta wires to the driven element. The hose clamps are left in place to clamp the insulated portion of the wires to the element as a strain relief.

In running the 300-ohm feedline into the shack, 3/4-inch PVC water pipe can be used as a feed-through bushing. Seal the ends with automotive silicon gasket sealer. Keep all bends in the feedline to at least a 6-inch radius, and maintain the feedline at least 4 inches from metal throughout its length. Another method of running a feedline into the shack is to replace a glass window pane with Plexiglas® that can easily be drilled to pass the line. Silicon sealer can be used to hold the line in place in the Plexiglas® pane.

As an aid to troubleshooting the system after it is erected, measure and record the resistance between the twin-lead wires at the end of the feedline. If the system ever fails to load to the transmitter, check the resistance; one of the wires in the ladder line may have broken.

Close-up of the 6-meter Yagi antenna.

Refurbishing Second-Hand TV Antenna Rotors

Second-hand TV antenna rotors may be obtained at low cost from TV antenna installers. Problems associated with used rotors are:

• Lubricant in the motor bearings and gears has oxidized to the point that the mechanism is stiff.

• The non-polarized electrolytic phase-shifting capacitor in the control box has failed due to age.

Remove the cover(s) from the rotor gear head and thoroughly clean out the old lubricant with a toothbrush and kerosene. Kerosene is a relatively safe solvent and won't harm electrical parts, but the work should be done outdoors. Carburetor spray cleaner is effective on stubborn lubricant, but may harm the motor winding insulation and other plastic parts. After the solvent has evaporated, re-lubricate the gears with a good grade of grease such as Mobilube EP2, and lubricate the motor bearings with gun oil such as Hoppe's.

Rotor control boxes generally contain a non-polarized electrolytic capacitor of about 50 μFd, 150 WV. Electrolytic capacitors of early vintage have a life of about 10 years, and the symptoms of a failed capacitor are failure to rotate or very slow rotation, much less than the nominal one revolution per minute. Replacement non-polarized electrolytics are available from some electronics suppliers, but two electrolytic caps, each of the same capacitance and voltage as the original NP cap, connected in series (+) to (+) are an equivalent. The modern caps are much smaller than the original, so there is no problem installing two in place of the one original cap.

Bench-check the reconditioned rotor with the length of control cable with which it will be used to assure that the system will work okay. As a final step in the bench-check, position the rotor to "N" and note this on the rotor case with a magic marker, to remind you to orient the beam north when the tower is erected. Before disconnecting the cable, mark the wire colors next to their terminals on both rotor and control box.

Second-Hand TV Antenna Towers

Although TV antenna towers are designed to be free standing, guy wires are recommended for the following reasons:

• The tower may have been weakened by rust and wind stress, so additional support is advisable.

• Guy wires facilitate raising and lowering the tower to work on the antenna.

The base of the guyed tower can simply be placed on a cement block. Prior to raising the tower, anchor the tower base to a steel fence post or other metal stake driven several feet into the ground to prevent the base from flipping up as the tower is raised. The grounded stake will also provide protection against lightning.

With the beam, feedline, and rotor installed on the tower and properly oriented, attach the four guy wires. Fourteen-gauge galvanized-steel electric-fence wire, available at farm stores, makes excellent guy wire. Anchor the two side guys to the ground at about a 45-degree angle to keep the tower from falling sideways as it is raised, and anchor the back guy so that the tower will stop in a vertical position.

Two people can then "walk" the tower vertical while a third person pulls on the front guy and anchors it when the tower is vertical. Guy wires should not be "banjo string" tight; a slight amount of slack is advisable to minimize stress. Bond the tower base to the stake with heavy wire for lightning protection.

A Simple 6-Meter Balanced Antenna Coupler

A simple 6-meter antenna coupler that will match 50-ohm coax to a balanced 300- or 450-ohm feedline can easily be built using two variable capacitors and a home-brew inductor. The coupler has sufficient range to compensate reasonable values of reactance presented by a feedline so that the SWR on the 50-ohm coax can be adjusted to 1:1.

Although the delta matching system is inherently narrowband, the coupler allows the antenna system to operate over a range of about 0.5 MHz above and below its design frequency, if the coupler is adjusted to maintain the SWR near 1:1 as seen by the transmitter. SWR on the balanced feedline may increase to 3:1 over this range, but because of the low-loss feedline, much less power will be wasted than if coax were used at a high SWR all the way to the antenna.

To make the inductor, obtain 3 feet of $^1/_8$-inch copper tubing or #10 bare copper wire. Tubing is easier to wind than solid wire. Clamp one end of the tubing in a vise. Leaving about 4 inches of tubing as a connecting lead, stretch the tubing straight and begin winding turns tightly together on a broom handle or other mandrel of about $^3/_4$ inch in diameter.

When $7^1/_2$ turns have been wound, allow an additional 4 inches for a connecting lead and cut the tubing. When released, the turns of the coil will spring to a slightly larger diameter and can be slipped off the mandrel. Now take a small piece of the tubing and run it around between the turns of the coil to space the turns from each other about one tubing diameter, or $^1/_8$ inch. Greater spacing between turns will increase the coil's inductance. Solder a wire to the center turn of the completed coil.

Two variable capacitors are required, one of about 100 pF and the second of about 35 pF. For transmitter power of 100 watts or less, the 100-pF cap can be salvaged from an old AC/DC broadcast radio. The smaller (oscillator) section of these capacitors is about 170 pF. The 35-pF cap will have higher voltage across it, so it is best to obtain a "short-wave" type capacitor for this application. Observe that both capacitor shafts are above ground potential, so suitable insulated control knobs must be used to avoid "hand capacitance" effects.

Mount the capacitors on a Masonite or other insulating panel with a coax connector and two binding posts for the feedline. The $7^1/_2$-turn copper-tubing coil is self-supported by soldering its three leads as shown in the schematic. A neat enclosure can be made of squares of Masonite held together by hot glue from an electric glue gun.

Test the coupler by connecting a 300-ohm carbon (non-inductive) resistor to the feedline terminals. Connect an SWR analyzer (or transmitter and SWR indicator) to the coupler input with a short length of 50- or 52-ohm coax. Set the analyzer's frequency to 50.4 MHz. Adjust both variable capacitors for an SWR indication of 1:1. Generally, both caps will be about half mesh (100-pF cap will be about 50 pF and the 35-pF cap about 17 pF).

Tips on Soldering Copper Pipe

Non-lead solder must be used to join pipe that will carry potable water; however, ordinary flux-cored "radio-TV" solder is satisfactory for use on antenna projects made of copper pipe or tubing.

The copper must be clean and bright to take solder. With steel wool, buff all areas that are to be soldered to remove all traces of oxide, and then immediately coat the areas with a paste flux such as NO-KORODE, to keep oxygen away from the metal. The paste flux augments the action of the solder's flux core.

Then assemble the joint and heat with a propane torch, while touching the solder to the joint. When the solder melts, feed it into the joint. By capillary action, the solder will be drawn into the joint.

Apply only sufficient heat to allow the solder to flow. Overheating will boil away the flux and the metal will oxidize quickly, so the solder will not "take." If this happens, let the metal cool and then rebuff with sandpaper or steel wool.

Soldering is best done in a warm (above 65° F) environment with no air movement. Trying to solder copper pipe in a winter windstorm can be very frustrating, as the heat is carried away quickly.

Development of the Copper-Pipe Beam and Tower

The 6-meter beam was tuned up and then installed with a reconditioned TV antenna rotor on a rickety old 30-foot TV tower. Due to the tower's condition and to avoid anchoring the base in concrete, four guy wires made of #14 galvanized fence wire broken up with electric fence insulators were used to support it. The tower was positioned in the garden such that if it fell, it would not contact the house, garden shed, or other antennas (telephone and power lines to the house are underground).

With the tower on the ground, the back guy wire and the two side guy wires were anchored to old pipes driven about 2 feet into the soil. The assembly was then easily pushed upright by two people, while the tower was kept from tipping sideways by the two side guy wires. A third person assisted by pulling on the front guy wire, and secured it to its stake when the tower was vertical.

During the raising operation, the back guy wire remained slack until the tower became vertical. Apparently, a kink formed in the wire during the time it was slack. After raising

the tower, I noticed the kink in the wire, about 5 feet above the ground. I thought, "I'll twist a jumper wire around the kink to strengthen the wire." Of course, I forgot to do this in my excitement in trying out the new antenna system.

The SWR and resonant frequency had not changed noticeably from the tuning that was done with the beam near ground level, and several new 6-meter beacon signals were heard that could not be heard on my 1/4-wave vertical.

About a week later, an evening storm came in from Lake Michigan, with winds up to 70 mph. I watched out the window and observed the feedline whipping vigorously as it disappeared up into the darkness. Suddenly, the feedline went slack!

Sadly, I took a flashlight and went out into the howling storm. On the ground lay my tower and beam; the back guy wire had broken at the kink. The wooden boom was undamaged, but the three copper-pipe elements were bent beyond repair.

Using the dimensions that were recorded when the original beam was tuned up, new copper-pipe elements were cut and installed. Special care was taken when the repaired beam was erected to ensure that none of the guy wires became kinked. The new beam has weathered several wind and ice storms over a period of a year with no problem. A concern that the wooden boom would warp and throw the elements out of alignment has not been realized; the pressure-treated wood is very stable. The reconditioned rotor continues to work even in near-zero weather.

Ordinary solid-web 300-ohm TV line was used as a feeder on the original beam. During rainstorms the SWR went up to about 2:1. However, the SWR could be brought back to 1:1 by adjusting the antenna coupler. Three-hundred-ohm "window"-type ladder line with stranded conductors was used on the repaired beam. Rain has no noticeable effect on this feedline.

Performance

A Yagi with three elements spaced 0.2 wavelength apart typically has a front-to-back ratio of about 12 dB, but the front-to-side ratio can be as high as 20 dB. At my QTH a steady carrier at 50.12 MHz can be heard about S8 (apparently, it is not a 6-meter beacon, as I have heard no modulation or Morse identification). The carrier must be nearby, as it appears to be unaffected by propagation phenomena.

The "mystery" signal provides a convenient means to evaluate 6-meter antennas! Rotating the beam to place its back-side to the signal causes the signal level to drop nearly into the noise level. Off the sides of the beam, the signal completely disappears in sharp nulls.

Postscript

An initial concern about the lack of durability of the wooden boom seems to have been unfounded at this point. From the ground, it does not appear to have warped despite the variables of the Michigan weather, and it is still aesthetically a pleasant sight to see.

In spite of its endurance and eye appeal, however, it has yet to perform during the big opening, the most recent one missed on December 19, 2005. Unfortunately, while my wife Norma, KA8EHE, and I were at a movie, the locals were working hundreds of stations during our absence. Sadly, as of yet the beam has not been able to perform its magic on the Magic Band. ■

IC-7000 Review *(from page 11)*

While the IC-7000 has a spectrum scope like the IC-756PRO radios, it is not as functional as the bigger rigs.

tial to drastically reduce the effects of any sort of ambient noise on operation. For example, ignition noise, even when not on channel, can cause AGC pumping that can make reception of a weak signal very difficult. Once the noise has been moved out of the IF passband, this effect is gone, unlike with more traditional configurations where the AGC would pump the receiver gain even from an off-channel signal.

Having said this, I have yet to have an opportunity to test the benefits of this. The IC-7000 also has many of the features of its big brothers, including twin digital passband tuning and dual manual notch filters. The 7000 is the first radio with dual notch filters, which is pretty cool if used to reduce sideband images around a signal. By using the notch to eliminate sidebands that are pumping the AGC, the AGC is allowed to act directly on the signal you are trying to receive (this is a key benefit of having the DSP in the AGC loop). This dramatically affects the S/N radio and causes a signal to just pop out.

Overall

The IC-7000 has a significantly extended set of CI-V commands for remote programming of the radio. It will be interesting to see all of the software programs that emerge to control the IC-7000. Voice record and playback is a new feature for this size radio and one which should help all of us VHF+ rovers who aren't carrying big rigs with us in the field. A high-stability oscillator is now part of the standard radio, which should help out with digital modes.

Overall I'm very impressed with what ICOM has been able to pack into the IC-7000 chassis, and I'm looking forward to gaining more operating experience with such a fine radio. ■

Factor	Typical Value
Frequency	144 MHz
Distance	500 km
Climate	Temperate
Surface Refractive Index	320
Obstructions	Nil—smooth Earth

Table 2. Constant values applied to the various factors used in comparison.

based on an empirical formula for a temperate climate only. There are differences of 5 dB among these methods for a smooth Earth, and all give significantly different losses for obstruction. A problem with these methods is that they are complicated to use and this can lead to errors.

Detailed Comparisons

The ARRL's *UHF/Microwave Experimenters Manual*[2] method and the three CCIR methods all take into account the more important variables. These are now compared to see the impact on the calculated results of varying different factors. The factors are individually varied, with the remaining factors being held constant at typical values as set out in Table 2.

Frequency

The four methods are in agreement that losses increase as the cube of frequency or 30 Log f in dB terms. The CCIR report[1] states that the results have not been validated outside the range 200 MHz to 4 GHz. There is some evidence in the amateur literature that at lower frequencies as the wavelength becomes much larger than the scattering cells the relationship with frequency may not hold and this may impact on the accuracy of the methods at 50 MHz.

Distance

As shown in figure 2, there are differences among the four methods over typically a 6-dB range. The odd kink and increased detail of CCIR method 1 reflects the fact that it takes specific account of the variation of scattering losses with height for each climate.

Surface Refractive Index

The radio refractive index at the surface has the effect of bending the wave to the scattering layer, slightly reducing the scattering angle and thus the scattering losses.

Both CCIR method 1 and the CCIR Chinese methods make allowance for surface refractive index as shown in figure 3. CCIR method 2 has separate graphs for temperate and tropical climates, and these may include allowance for radio refractive index. However, they would also be affected by changes of scattering properties with climate, so the refractive index component is difficult to isolate.

CCIR method 1 indicates refractive index is more important at shorter distances and/or low obstruction angles where a significant part of the path is within a few km of the surface. It indicates that a variation of refractive index from 320 to 380 can have an impact of 5 dB at short distances, reducing to 2 dB for long paths (over 500 km) or where there are a few degrees of obstruction. The Chinese method applies a constant correction for surface refractive index independent of distance or obstruction angles; this is not logical, and the approach is considered deficient in this respect.

Climate

The CCIR Chinese method applies only to a temperate climate, and while not generally specified, it is likely that most amateur methods are also based on a temperate climate. Only CCIR methods 1 and 2 take into account different climates. CCIR 2 provides graphs of the basic propagation loss for a temperate and tropical climate and shows a variation that is relatively small at short distances, increasing to 6 dB at 1000 km. CCIR 1 gives information to adjust for six of the eight climates it specifies and shows variations of up to 15 dB between a mar-

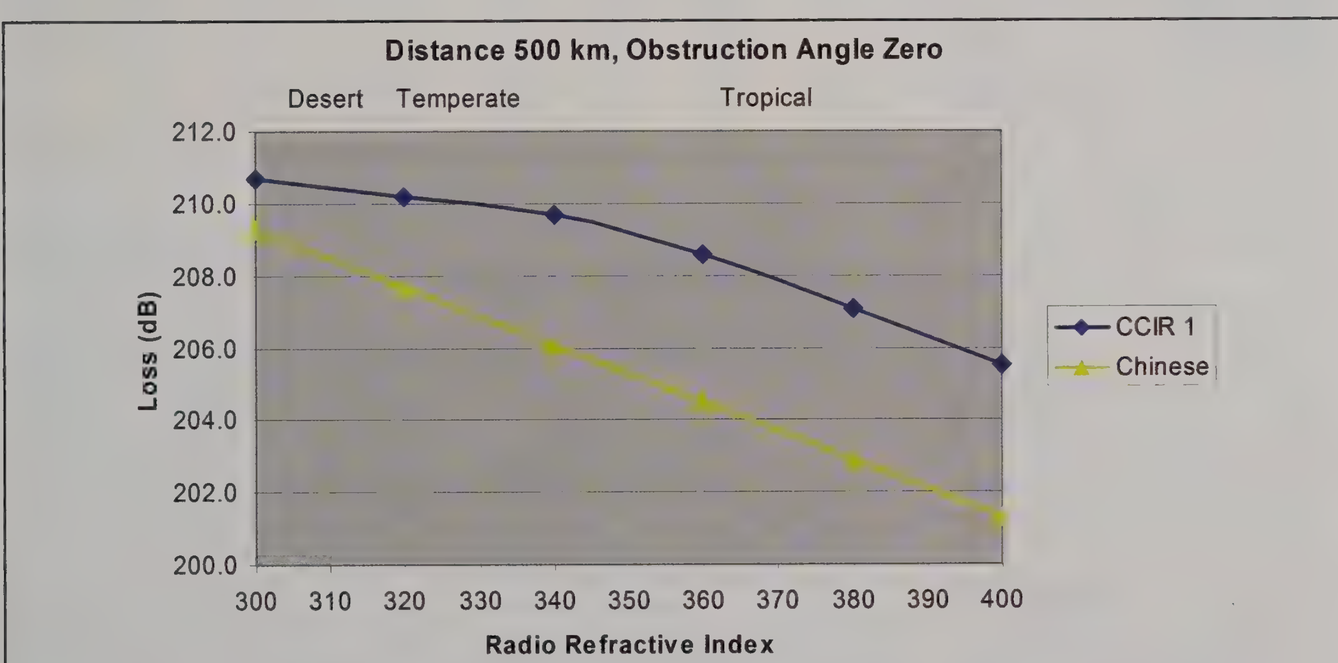


Figure 3. Variation of propagation loss with surface radio refractive index.

APPENDIX A: Propagation Losses

Applies to 50% path reliability, temperate climate, and radio refractive index of 320.

6 Meters

km	0 deg	1 deg	2 deg	3 deg	4 deg	5 deg	6 deg
100	155.3	165.7	171.9	176.6	181.9	187.9	189.9
150	164.4	172.6	180.6	187.0	189.6	191.8	193.7
200	170.3	181.8	186.2	189.2	191.8	195.7	199.1
250	178.8	183.8	187.3	191.6	196.0	199.6	202.8
300	181.1	185.2	190.7	195.5	199.5	203.0	206.2
350	182.9	189.4	194.7	199.1	203.0	206.5	209.5
400	187.4	193.5	198.4	202.7	206.4	209.7	213.9
450	192.1	197.5	202.3	206.3	210.5	214.9	218.9
500	196.4	201.6	206.1	210.9	215.6	219.6	222.8
550	200.6	205.4	210.8	215.9	219.9	223.3	226.6
600	204.4	210.2	215.7	219.9	223.5	227.2	230.7
650	209.2	215.2	219.6	223.5	227.5	231.2	234.6
700	214.2	219.0	223.2	227.6	231.4	235.0	238.2
750	218.2	222.7	227.3	231.4	235.1	238.5	241.6
800	221.8	226.7	231.1	235.0	238.6	241.9	244.9
850	225.9	230.5	234.7	238.5	241.9	245.0	—
900	229.8	234.2	238.2	241.8	245.0	—	—
950	233.4	237.6	241.4	244.9	—	—	—
1000	236.9	240.9	244.5	—	—	—	—

2 Meters

km	0 deg	1 deg	2 deg	3 deg	4 deg	5 deg	6 deg
100	169.1	179.5	185.7	190.4	195.7	201.7	203.7
150	178.2	186.4	194.4	200.8	203.4	205.6	207.5
200	184.1	195.6	200.0	203.0	205.6	209.5	212.9
250	192.6	197.6	201.1	205.4	209.8	213.4	216.6
300	194.9	199.0	204.5	209.3	213.3	216.8	220.0
350	196.7	203.2	208.5	212.9	216.8	220.3	223.3
400	201.2	207.3	212.2	216.5	220.2	223.5	227.7
450	205.9	211.3	216.1	220.1	224.3	228.7	232.7
500	210.2	215.4	219.9	224.7	229.4	233.4	236.6
550	214.4	219.2	224.6	229.7	233.7	237.1	240.4
600	218.2	224.0	229.5	233.7	237.3	241.0	244.5
650	223.0	229.0	233.4	237.3	241.3	245.0	248.4
700	228.0	232.8	237.0	241.4	245.2	248.8	252.0
750	232.0	236.5	241.1	245.2	248.9	252.3	255.4
800	235.6	240.5	244.9	248.8	252.4	255.7	258.7
850	239.7	244.3	248.5	252.3	255.7	258.8	—
900	243.6	248.0	252.0	255.6	258.8	—	—
950	247.2	251.4	255.2	258.7	—	—	—
1000	250.7	254.7	258.3	—	—	—	—

itime temperate climate over sea and a desert climate. For those who might live in the outback or the tropics, the climate variations can be significant and are only fully taken into account with CCIR method 1.

Obstructions

Figure 4A shows there are significant differences between the four methods, and that with 5 degrees of obstruction (2.5 degrees at each station) the differences between the methods are as much as 25 dB. In amateur situations, obstruction angles of 2.5 degrees at each end are not uncommon, and thus this variation represents a major concern in calculating tropospheric-scatter losses.

In order to explore this issue, figures 4B and 4C give the data at 200 km and 800 km. Figure 4C shows that at short distances and small angles there is much closer agreement between all methods. At 800 km, as shown in figure 4C, it is seen that all three CCIR methods are substantially less than the 10 dB per degree approach used by the ARRL *UHF/Microwave Experimenter's Manual*[2] method.

The 10 dB per degree approach and the CCIR Chinese method both are based on empirical equations. It is possible that these equations do not hold over a wide range of distances and angle. However, both CCIR methods 1 and 2 are intended to apply over the range of data graphed and still show large variations. The only

APPENDIX B: Propagation Losses

Applies to 50% path reliability, temperate climate and radio refractive index of 320.

70 cm

km	0 deg	1 deg	2 deg	3 deg	4 deg	5 deg	6 deg
100	183.4	193.8	200.0	204.7	210.0	216.0	218.0
150	192.5	200.7	208.7	215.1	217.7	219.9	221.8
200	198.4	209.9	214.3	217.3	219.9	223.8	227.2
250	206.9	211.9	215.4	219.7	224.1	227.7	230.9
300	209.2	213.3	218.8	223.6	227.6	231.1	234.3
350	211.0	217.5	222.8	227.2	231.1	234.6	237.6
400	215.5	221.6	226.5	230.8	234.5	237.8	242.0
450	220.2	225.6	230.4	234.4	238.6	243.0	247.0
500	224.5	229.7	234.2	239.0	243.7	247.7	250.9
550	228.7	233.5	238.9	244.0	248.0	251.4	254.7
600	232.5	238.3	243.8	248.0	251.6	255.3	258.8
650	237.3	243.3	247.7	251.6	255.6	259.3	262.7
700	242.3	247.1	251.3	255.7	259.5	263.1	266.3
750	246.3	250.8	255.4	259.5	263.2	266.6	269.7
800	249.9	254.8	259.2	263.1	266.7	270.0	273.0
850	254.0	258.6	262.8	266.6	270.0	273.1	—
900	257.9	262.3	266.3	269.9	273.1	—	—
950	261.5	265.7	269.5	273.0	—	—	—
1000	265.0	269.0	272.6	—	—	—	—

23 cm

km	0 deg	1 deg	2 deg	3 deg	4 deg	5 deg	6 deg
100	197.7	208.1	214.3	219.0	224.3	230.3	232.3
150	206.8	215.0	223.0	229.4	232.0	234.2	236.1
200	212.7	224.2	228.6	231.6	234.2	238.1	241.5
250	221.2	226.2	229.7	234.0	238.4	242.0	245.2
300	223.5	227.6	233.1	237.9	241.9	245.4	248.6
350	225.3	231.8	237.1	241.5	245.4	248.9	251.9
400	229.8	235.9	240.8	245.1	248.8	252.1	256.3
450	234.5	239.9	244.7	248.7	252.9	257.3	261.3
500	238.8	244.0	248.5	253.3	258.0	262.0	265.2
550	243.0	247.8	253.2	258.3	262.3	265.7	269.0
600	246.8	252.6	258.1	262.3	265.9	269.6	273.1
650	251.6	257.6	262.0	265.9	269.9	273.6	277.0
700	256.6	261.4	265.6	270.0	273.8	277.4	280.6
750	260.6	265.1	269.7	273.8	277.5	280.9	284.0
800	264.2	269.1	273.5	277.4	281.0	284.3	287.3
850	268.3	272.9	277.1	280.9	284.3	287.4	—
900	272.2	276.6	280.6	284.2	287.4	—	—
950	275.8	280.0	283.8	287.3	—	—	—
1000	279.3	283.3	286.9	—	—	—	—

saving grace is that they are very close at the larger distances that are of most interest (800 km).

Aperture to Medium Coupling Loss

Three of the methods provide a means of calculating the coupling loss which arises when the antenna gains reach a level at which only a small part of the effective scattering volume is utilized (see figure 5).

Both of the CCIR methods give similar results and show that these losses are on the order of no more than a dB, providing antenna gains do not exceed 25 dBi at each end. Thus, for most VHF and UHF amateur situations they will not be a significant factor. The ARRL *UHF/Microwave Experimenter's Manual*[2] method has a constant of 2 dB plus an amount related to antenna gain. It is difficult to see the logic for this constant, so this method is not preferred.

Path Reliability

For amateur operations it is sufficient to work on the basis of 50% path reliability, as if information is missed, it can be repeated. It is likely that most methods in amateur texts are based on 50% path reliability, but few specify the level on which they are based. CCIR method 1 provides data for a range of path reliabil-

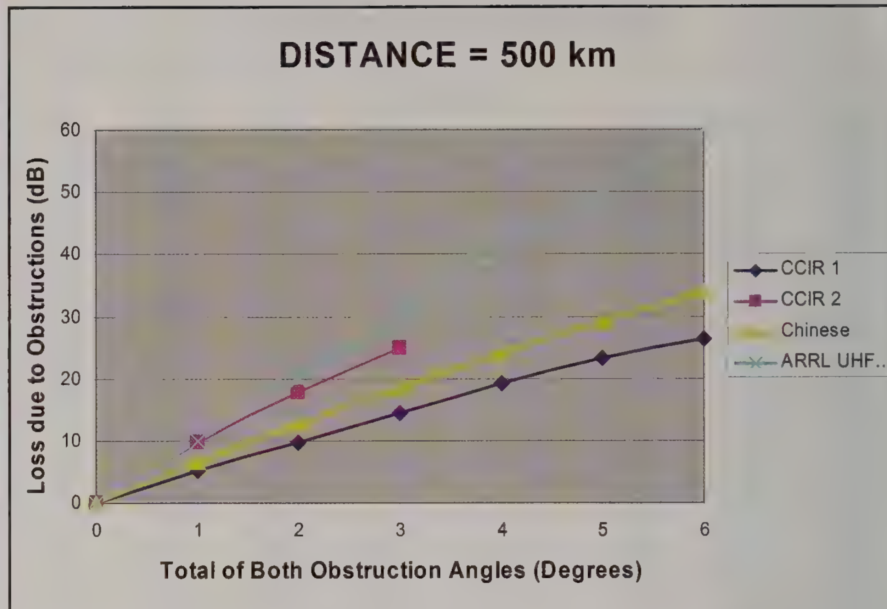


Figure 4A. Variation of loss due to obstructions at 500 km. The graph provided with CCIR-2 limits the calculation of losses with this method to a little over 3 degrees at 500 km.

ities for various climates and distances. The data show that moving from 50% path reliability to 90% can add up to 10 dB to the propagation loss. CCIR method 2 provides similar data for both temperate and tropical climates with similar variations. The CCIR Chinese method is provided for 50% path loss only. Given that the propagation loss is required for 50% path reliability, any of the CCIR methods are suitable, in this respect, and are basically consistent.

Assessment and Conclusion

It is noted that of the four methods considered most promising, there are a number of minor differences. However, a major difference arises in the way that obstruction losses are determined. Both the ARRL *UHF/Microwave Experimenter's Manual*[2] method and the CCIR Chinese methods are based on empirical formulas and could well have limited

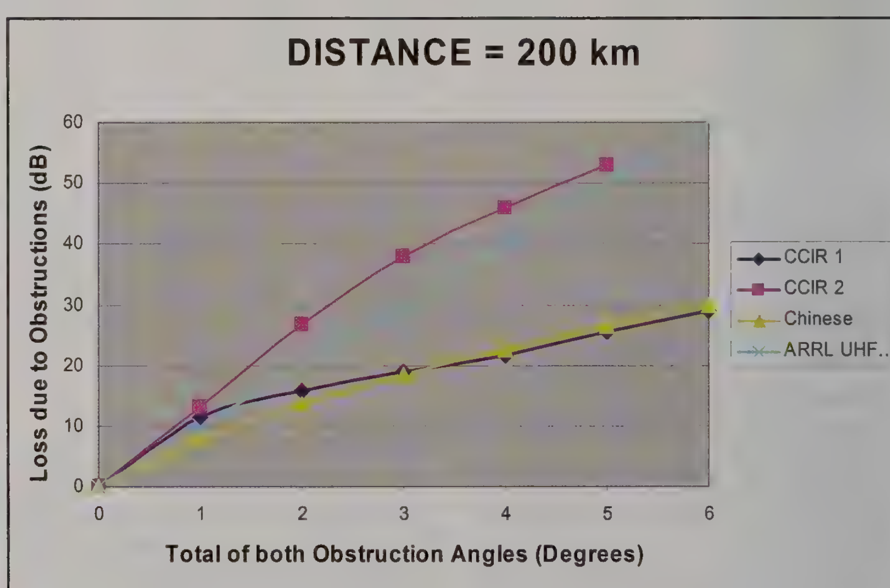


Figure 4B. Variation of loss due to obstructions at 400 km. The graph provided with CCIR-2 limits the calculation of losses with this method to a little over 5 degrees at 200 km.

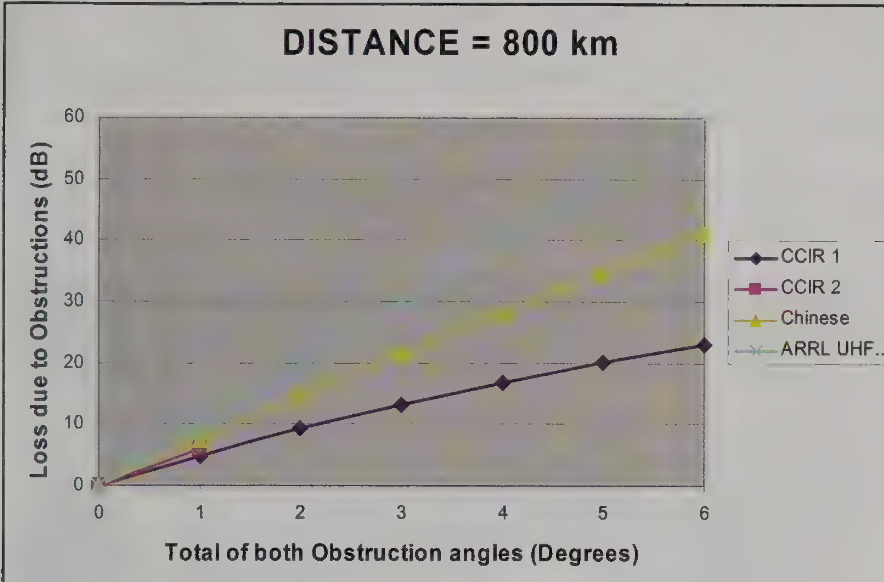


Figure 4C. Variation of loss due to obstructions at 800 km. The graph provided with CCIR-2 limits the calculation of losses with this method to a little over 1 degree at 800 km.

application in the situations thatare of our prime interest—longer distances combined with obstructions. The major differences between CCIR methods 1 and 2 in relation to obstruction loss are a concern, but at least they are close at the longer distances that are of most interest. CCIR method 1 is based on work by the US National Bureau of Standards, which perhaps gives it more credibility. It also includes the widest range of climates and all other variables.

In the absence of an independent way of deciding which is the correct method, I will resort to concluding that on the balance of probabilities, CCIR method 1 is to be preferred. The major problem with this method for amateur use is that it is complicated to use and this can lead to errors. So as to allow amateurs the opportunity to take advantage of it, I have prepared a set of tables at Appendix A and Appendix B that set out the propagation loss based on CCIR method 1 for the bands 6 & 2 meters and 70 cm & 23 cm. These cover distances from 100 km to 1000 km and total obstruction angles (the total of those for both stations) from zero to 6 degrees. Aperture to medium coupling losses are assumed to be small, but should be added if antenna gains are more than 25 dBi at each end (see figure 5). The tables are based on 50% path reliability, temperate climate, and a refractive index of 320 and should be applicable to southeastern Australia. For those who live in other areas, it will be necessary to go to the original CCIR report. As an approximation, applicable for distances beyond 600 km, reduce the figures by 4 dB in the tropics and increase them by 9 dB in desert regions. ■

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3. *The VHF/UHF DX Book* edited by Ian White, G3SEK.
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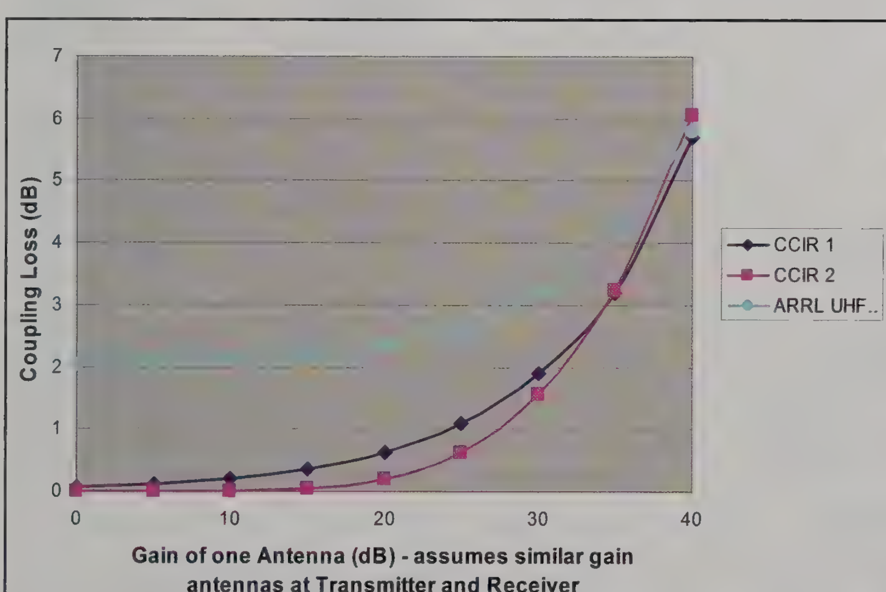

Figure 5. Aperture to medium coupling losses.

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

When Did We Become Obsolete?

Think back, if you are old enough (and if you are a member of The SETI League, demographics suggest you most likely are), to the exciting days of October 1957. The world's first artificial satellite, Sputnik 1, had just been placed in orbit. It was launched by the USSR (that area of the world had been known by this acronym for two generations, although in America they still were collectively referred to as "The Russians"). If you, like me, were living in the U.S. at the time, you were being told that the USSR was an enemy nation, the Russians an enemy people. Your enemy was in space; you could hear them on 20 Mc (this was in the days before MHz)! America was suddenly a paranoid nation.

Think back, if you are old enough (and if you're a radio amateur, statistics suggest you most likely are), to the frantic days immediately following Sputnik. The United States was trying desperately to play catch-up. Your high school guidance counselor was telling you, "You're good at science. You're good at math. Go and become an engineer; we will never have enough engineers to catch up to the Russians." (At the same time, you learned years later, your friend Sasha Zaitsev in the USSR was being told by his high school guidance counselor, "You're good at science. You're good at math. Go and become an engineer; we will never have enough engineers to stay ahead of the Americans.")

Think back, if you are not yet senile (and if you're able to read this, there is still hope), to when you first got your ham radio license. The world that Sputnik had made smaller was suddenly shrinking even more. You could talk (okay, so it was probably via Morse Code) to other hams halfway around the world—maybe even to the dreaded Russians. Maybe they weren't your enemy after all.

Think back, if you are old enough (and if you've read this far, I know you are), to the excitement of December 1961. With a little help from your USAF friends, a handful of ham radio operators had just launched OSCAR I, the world's first non-government satellite. You could hear it on 145 Mc (this was still in the days before MHz)! Suddenly schools (the same ones that were training Americans to catch up with the Russians, and the same ones that were training Russians to stay ahead of the Americans) were activating ham radio clubs, building antennas, and pointing them . . . up!

*Executive Director, The SETI League, Inc., <www.setileague.org>
e-mail: <n6tx@setileague.org>

Look around. Do you see many young faces in the crowd at a typical SETI League meeting? Well, neither do I. We all are becoming graybeards, and if that doesn't concern us, perhaps it should. (WA2UNP photo)

Now think back to last week. Surely you're old enough to have noticed your kid (or maybe your grandkid) Instant Messaging to his buddies in Russia. Maybe he/she doesn't remember what USSR stood for, but he/she knows all the countries in the world by their e-mail suffixes. Never mind that those same international suffixes used to be ham callsign prefixes. What matters is that your offspring are talking to the world via IM and e-mail and VoIP (Voice over Internet Protocol) and cell phones—and yes, even via satellite links, links invisible to them. Do you think they have any need for ham radio? Probably no more than we have need for spark. The world has passed us by.

Or has it? Are there a few things we can still teach our kids, our grandkids, before they put us out to pasture? I like to think there are.

Think forward to a world linked by a telecommunications infrastructure that rivals science fiction's boldest predictions. Every man, woman, and child carries a communicator (possibly implanted) that links him or her to everyone else on Earth—instantly, and cheaply, via satellite, in whatever language the participants choose. You thought Paramount Studios held all the patents on the Universal Translator/Communicator? So did I. However, it wasn't long before this technology permeated our society . . . and transformed it.

Now think far forward and about a civilization in decline. For generations, our descendants took for granted a technological base that unified their world. Nobody needed ham radio; it was obsolete, overtaken by progress. Nobody needed The SETI League; it was a vestige of a bygone era, a footnote in the history books. All anybody needed was to think the right words, and the neural interface self-activated, putting any individual in instant contact with any other, at

the speed of thought. The omnipresent satellites were invisible not only to their eyes, but to their mind's eye as well.

Until they began to fail. Our machines, like ourselves, are mortal. Suddenly, there was nobody on Earth who remembered Keplerian elements. There was nobody alive who remembered Maxwell's Equations. Right ascension and declination might as well have been mystical incantations to a long-dead god. The global net fell silent, and not a soul had a clue about how to fix it.

Fortunately, a group of anthropologists and historians remembered something from their school days, a primitive creature, cryogenically preserved, who had roamed the Earth in those prehistoric days when satellites were new, and Russians and Americans thought themselves enemies. A being who used ancient, stone-age tools such as dishes and LNAs and frequency synthesizers and digital signal processing to squeeze out crude, low-information-content signals from the stars.

Thus, they thawed out this creature and put him to work, and he saved the world.

He was an amateur radio astronomer.

He was a SETI League member.

He was you.

73, Paul, N6TX

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